LUNG ABSCESS

BY

R. C. BROCK

M S , F R C S , F A C S

Thoracic Surgeon to Guy's Hospital, Surgeon to the Brompton Hospital, formerly Consulting Thoracic Surgeon to the London County Council

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LUNG ABSCESS

INTRODUCTION

This monograph is based on a series of essays which appeared in the Guy's Hospital Reports between 1945 and 1948 and were conceived as a result of the study of the clinical, anatomical, and pathological features of the not inconsiderable number of patients with lung abscess whom I have seen and treated during the last twenty years. The actual number used for the various statistical analyses is 477. Much has been written about lung abscess but our knowledge is still far from complete, and it is certain that the knowledge that already exists is only indifferently disseminated.

[illegible]

of mind that tends to be engendered as a result of the wide acceptance of conservative treatment

Because of the clinical and radiological demonstration of a formed abscess cavity in the lung the impression is again engendered that one is dealing with a clinical entity of 'lung abscess.' This is also an error and leads to a complacent grouping together of a number of conditions which are widely different in their causation, clinical course, and end result. It is one of the objects of this presentation to try and differentiate some of the types of lung abscess and to explain their varying aetiology and natural history.

It must be emphasized that a diagnosis of 'lung abscess' is insufficient. A lung abscess is almost always secondary to something else; it is much less often a true primary condition It may be a clinical triumph and source of satisfaction to diagnose a difficult case conclusively as 'lung abscess,' for instance, as opposed to growth or empyema; it may be only too obvious that the patient has a lung abscess. In neither case must the diagnosis rest there, but must be followed to its logical conclusion; namely, what is the true primary cause of the abscess? It may, at times, be impossible to elucidate this primary cause or to be certain of it, but the search must be made. Unfortunately, complacency has again been engendered by the statement that a fair proportion, variously estimated, of lung abscesses are 'idiopathic.' In part this is true, but its acceptance stultifies all attempts to improve our knowledge of the condition. A special chapter will deal with this question of the diagnosis of the primary cause of lung abscess, but the principle is postulated now as it will be a guiding theme running through all the chapters.

I am greatly indebted to the Guy's Hospital Reports Committee for permission to make use of the blocks of the illustrations used in this book.

CHAPTER I

BRONCHO-PULMONARY SEGMENTAL ANATOMY

It is impossible to understand lung abscess without a clear knowledge of broncho-pulmonary segmental anatomy, and therefore an account of lung abscess must necessarily start with a description of this anatomy. It is almost axiomatic that the study of the disease processes of any organ or system must rest primarily upon a knowledge of the related anatomy and physiology. The modern approach to disease really dates from the time when the need for this exact study was generally realized and followed. The older anatomy of Galen was swept away by Vesalius; Harvey's physiological studies did the same for the mediaeval approach to function The application of such basic methods in the study of the normal and abnormal led to the great advance of the succeeding centuries. It is remarkable that in the study of diseases of the lung a gap existed. It is true that the classic observations of Laennec and many others taught us a great deal about the pathology and clinical aspects of lung diseases, but the knowledge of pure anatomy on which this was based was incomplete; it dealt only with the gross structure of the lung, going no further than a consideration of the lobes as possible units. If less than the lobes were considered the descriptions and observations were to a great extent empiric because there was little or no ordered anatomy as a guide. In this respect the study of lung diseases may be fairly described as remaining in a mediaeval state. Towards the end of the nineteenth century the studies of Aeby and of Ewart began to draw attention to the more detailed anatomy of the bronchial tree, but it was not until the second quarter of the present century that a significant advance was made This was the recognition of the importance of the broncho-pulmonary segment as a unit and a wide appreciation of the need for application of this segmental anatomy in the study and management of lung diseases. One reason, perhaps the chief, for this development was the rapid advance made in thoracic surgery. The white light of surgery illumines many dark places, and the need for more exact diagnosis before the serious step of operation is embarked upon encourages an exactitude and precision that is otherwise not found to be so necessary. As soon as the importance of this broncho-pulmonary segmental anatomy is grasped and it is consistently applied to the study and management of pulmonary disease a great deal of new information is inevitably revealed. It so happens that the suppurative diseases of the lungs depend to an unusually large degree on the anatomical arrangement of the broncho-pulmonary segments and, as already stated, it is not possible to study or understand these

diseases intelligently without a clear conception of this anatomy, which is of course also important in all inflammatory lung conditions. The recognition and general acceptance of the importance of broncho-pulmonary segmental anatomy is undoubtedly one of the great advances in the management of pulmonary diseases in this half-century.

It is not possible in this book to give a full account of broncho-pulmonary anatomy; this in itself provides the material for a book. For a fuller account the reader is referred to the various articles mentioned in the bibliography and to the series of papers written by the author in the Guy's Hospital Reports or to the book in which these papers were collected.

Nomenclature

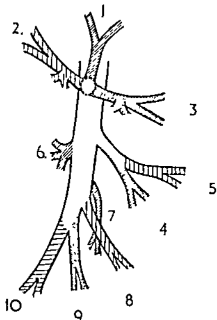
Descriptions of the anatomy of the bronchi have been given by a number of authors during the last ten to fifteen years, and although there is fairly general agreement on the arrangement of almost all the chief branches, there have inevitably been differences in nomenclature as many authors have put forward their own scheme The Thoracic Society recently appointed a sub-committee to draw up a uniform nomenclature, and soon after this the occasion of the International Congress of Otorhinolaryngology in London in July, 1949, provided an unusual opportunity to try and obtain agreement on an international plane, accordingly a representative committee was formed and a scheme approved by all was worked out This was submitted to the Thoracic Society and was accepted; the agreed new international nomenclature was published as a report in *Thorax* in September, 1950. This new nomenclature, which will be used throughout this book, is shown in Figure 1.

In order to help the simple identification of the chief segments each is allotted a number; it will be noticed that the absence of the medial basal (cardiac) bronchus and segment on the left means that there is no number 7 on that side

It is wrong to consider the bronchi without the actual lung segments that they supply, these can be accurately demarcated by injection with a coloured solution of gelatin. In this way a pattern or map of the lung segments can be obtained (Figures 2 and 3).

The diagrams depict the average general position, shape, and size of the segments, but there are naturally variations from case to case. For instance, the anterior segment of the right upper lobe may be larger at the expense of the posterior segment, or vice versa. Allowing for such variations, the pattern is conformed to often enough to be accepted as a standard

It will be noted that lateral and medial views alone have been used in these diagrams; this is in marked contrast to the habit, still only too common, of relying solely or chiefly upon postero-anterior radiographs of the lungs for study. Each lung is far wider in its lateral view than in the postero-anterior,



UPPER LOBE

1 Apical bronchus
2 Posterior bronchus
3 Anterior bronchus

MIDDLE LOBE	LINGULA
4 Lateral br.	4 Superior br
5 Medial br	5 Inferior br

LOWER LOBE

←	→
6 Apical bronchus	6 ditto
7. Medial basal (cardiac) br	
8 Ant basal br.	8 ditto
9 Lateral " ".	9 ditto
10 Post. " ".	10 ditto

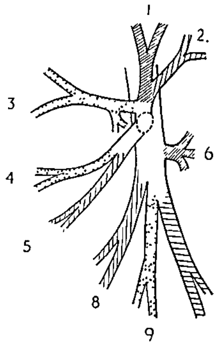


Fig. 1. The nomenclature of the bronchial tree.

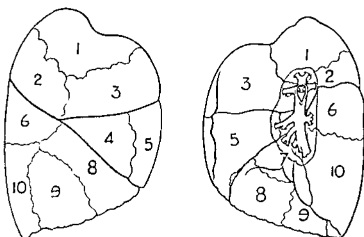


FIG 2 The segments of the right lung

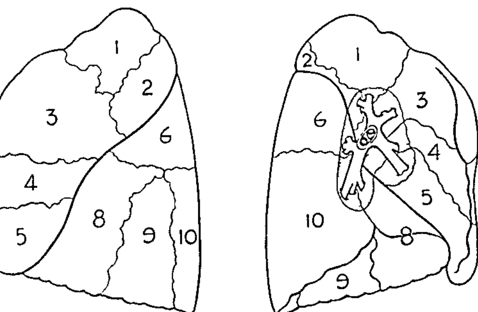
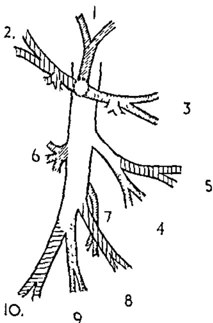


FIG 3 The segments of the left lung



UPPER LOBE

1 Apical bronchus
2 Posterior bronchus
3 Anterior bronchus

MIDDLE LOBE	LINGULA
4 Lateral br.	4 Superior br
5 Medial br	5 Inferior br

LOWER LOBE

←	→
6 Apical bronchus	6 ditto
7. Medial basal (cardiac) br	
8 Ant basal br	8 ditto
9 Lateral " "	9 ditto
10 Post. " ".	10. ditto

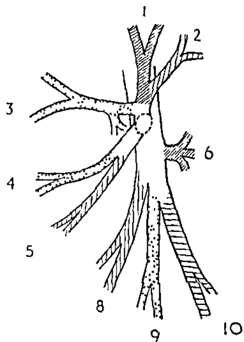


Fig 1. The nomenclature of the bronchial tree.

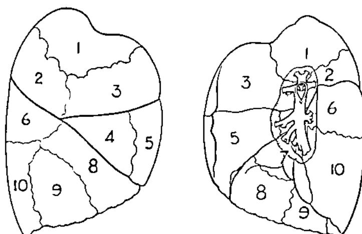


Fig 2 The segments of the right lung

Fig 3 The segments of the left lung

even though the total width of the chest may be wider. For this reason alone the radiological study of the lungs and bronchi would be incomplete without

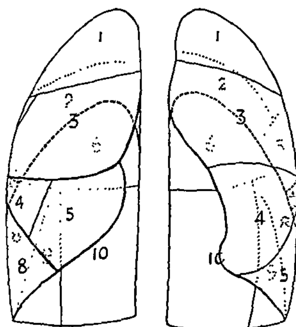


Fig 4 Antero-posterior diagram of the segments to illustrate overlap and confusion.

lateral as well as postero-anterior views. More important still is that the lateral views avoid the considerable overlapping and confusion that occurs in a postero-anterior radiograph. This is well shown in the diagrams of the segments in Figure 4. The same overlapping is also seen in postero-anterior bronchograms, whereas in the lateral view the bronchial anatomy is seen quite clearly (Figures 25*b* and 27*d*).

The indispensability of good lateral as well as postero-anterior radiographs is now widely recognized, but it is still only too common to find radiologists giving a report on a lung lesion from a postero-anterior film alone and, what is even more disturbing, to find clinicians accepting such incomplete examinations and reports. It is by no means uncommon to find a case of lung suppuration has been observed over a course of many weeks, or even months, without a single lateral radiograph being taken. This failure of appreciation of the need for *exact anatomical localization and anatomical study* of the lesion as the first step in diagnosis is really a perpetuation of the mediaeval approach to medicine and surgery already mentioned. It is impossible to approach diagnosis and management intelligently until exact localization has been considered. For this reason the use of such loose terms as 'upper zone,' 'middle zone,' and 'lower zone' is to be deprecated.

If radiological opacities are studied in this way on the basis of the standard arrangement of the broncho-pulmonary segments it will be found that it is common to be able to recognize that a particular segment is accurately demarcated; Figures 5 and 6 show examples of this It is possible to illustrate examples of typical lesions of every segment in the lungs, but space prevents this. A full account will be found in the book already mentioned (Brock, 1946). Once this principle has been grasped it will be found that with practice and a simple application of anatomical knowledge a whole flood of light is thrown on the radiological and clinical study of lung diseases, especially the suppurative group. Difficulties and sometimes confusion occur from ill-defined lesions, from multi-segmental lesions, or from overlap or irregularities, but these will not affect the main principle, and at any rate should serve to stimulate effort to elucidate them.

The advantages to be derived from this approach to lung suppuration on a segmental anatomical basis are

1. The ability to localize the lesion to its exact anatomical site.
2. The indispensable value this has in differential diagnosis.
3. The confidence engendered by the knowledge that one's approach is more exact and specific and not empiric.
4. The fuller observation of the natural history and pathology that is rendered possible
5. The inevitable advance in basic knowledge that ensues
6. The proper prescription of postural drainage or of topical therapy within the bronchial tree
7. The assessment of the exact external operative approach to a lung abscess.

CHAPTER II

THE PATHOLOGY OF LUNG ABSCESS

LUNG abscess is essentially an acute suppurative pneumonitis which ı proceed to a greater or lesser degree of gangrene. All gradations of gangı occur, presumably due to variations in the resistance of the host and virulence of the infecting organisms. As the process that gives rise to abscess is suppuration occurring in an area of pneumonitis, it is necessar consider how this area of pneumonitis arises. Because gangrene is such important feature the question of arterial embolism as the primary caus inevitably raised. Although this must occasionally happen, it is doubtful is the process in all but a few cases. The primary event is almost certai *bronchial embolism* by some substance that carries with it organisms, anaero or aerobic (often mixed or symbiotic), and frequently of the types commo found in the mouth and nasal passages. This embolism sets up an ac segmental or subsegmental pneumonitis which, presumably by causing seco dary vascular thrombosis or by direct toxic action upon the lung tissue, gi rise to gangrene of the lung. Cutler and Schluetter (1926) and Cutler (192 from experimental studies on dogs, have shown that a lung abscess could caused only if both bronchial *and* vascular embolism was instituted. It is r possible to correlate their observations with the condition as it occurs in ma

Bronchial embolism and posture

e common
This matt
ation (Broc
Hodgkiss, and Jones, 1942). One of the most pertinent and conclusive fac in the evidence is the occurrence of abscess in certain sites in the lung whi are peculiarly favourably placed to receive inhaled material in certain cor mon postures. If a careful anatomical assessment is made of the segment localization of inflammatory lung lesions (tuberculous as well as no tuberculous, before continued spread has obscured the picture), it will found that certain segments are much more commonly involved than other The first of these is, undoubtedly, the posterior segment (segment 2) of th right upper lobe (Figure 5); the same segment on the left side is less ofte affected. This posterior segment of the right upper lobe can unhesitatingly b named as the most important segment in the lungs Next in order of frequenc is the apical segment of each lower lobe (segment 6, Figure 6). It is no ... to see segments 2 and 6 affected together, or consecutively.





FIG 5 Abscess of the posterior segment, right upper lobe In the postero-anterior view it is not possible to localize the segment involved In the lateral view the diseased posterior segment can be identified





FIG 6 Abscess of the apical segment of the right lower lobe

These are observations of fact, and the most satisfactory explanation of the occurrence is simple and shows the cause to be the distribution of inhaled

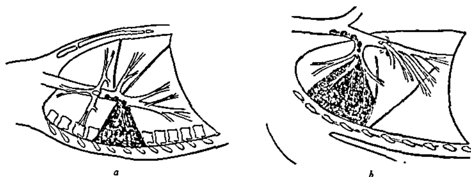


Fig 7 To show the suggested relationship between posture and the focal incidence of lung abscess When the patient is lying on his back (Figure 7a) the apical part of the lower lobe is vulnerable, and when lying on his side (Figure 7b) the lateral and posterior part of the upper lobe is affected

material within the bronchi (bronchial embolism) as a result of gravity and posture.

Thus, if a patient is lying on his back when material enters the bronchial tree the first bronchus favourable for its reception is the apical bronchus to the lower lobe (Figure 7*a*). If the subject is lying on his side, the upper lobe bronchus is similarly most favourably placed to receive the embolism (Figure 7*b*).

It is quite simple to confirm this mechanism by radiography of the chest after introduction of a small quantity of radio-opaque oil into the trachea with the patient lying on his side or on his back. Figures 8 and 9 show that the oil, in such circumstances, gravitates *at once* to the segments mentioned. and indeed quite a good selective bronchogram is obtained.

Moreover, when the subject is on his side he may be rotated forwards or backwards to a varying degree. This also will affect the site of reception of the embolus. Figure 10 is a diagram, but the disposition of the bronchi of the right upper lobe is drawn accurately from a metal cast. It will be seen that various combinations of lesions can occur, *and all of these are observable in practice and can be demonstrated time and time again.* With this simple knowledge applied to the radiological and clinical study of lung suppuration it is possible to understand a great deal that hitherto would have been obscure, meaningless, or empiric.

Similar, although less common but no less precise, examples of selective bronchial embolism may be observed throughout the lungs and many examples will be given in the later chapters. If this principle of the part played by posture and gravity in bronchial embolism is accepted and applied whenever possible it will be found to pay handsome profits in achieving, quite



a



b



c

FIG 8 Lipiodol injected with the patient lying on his back has entered the apical bronchus to the left lower lobe Figure 8*a* was taken after thirty seconds, Figures 8*b* and 8*c* after five minutes



a



a



b



b



FIG 9*a*, *b* and *c* all show almost identical results from injection of lipiodol when the patient is lying on his right side; in each case the right upper lobe alone is affected.

In most cases this inhaled material is dealt with effectively by the simple protective mechanisms of ciliary action and cough. If these protective mechanisms either fail or are inefficient, the stage is set for serious secondary changes. If the inhaled material is relatively small in amount, and especially if it remains fluid, it is likely to be expelled. The behaviour of blood can be taken as a good example of what can happen. A small amount of fluid blood will be evacuated by ciliary action, probably aided by cough; if clotting occurs, ciliary action is certainly rendered ineffective (Negus, 1934) and only coughing can clear the bronchi If the amount of clot is large or it has remained *in situ* long enough for secondary atelectasis to have occurred (e.g. two or three hours may suffice), coughing may be quite ineffective, especially if the power of the cough has been impaired by prolonged narcosis, prostration, muscular rigidity, or pain. The state of affairs is somewhat similar if muco-purulent material is considered; small amounts in a thin liquefied form are less dangerous; thick gelatinous or purulent material, especially if secondary drying occurs, or secondary dilution by intrabronchial mucus is prevented, is especially dangerous More dangerous still than thick fluid or clotted material is frank, solid particulate matter such as shreds of mucous membrane, fragments of tonsil or adenoids, fragments of tartar from the teeth (Stern, 1925; Smith, 1927), or inhaled vomit. Large foreign bodies, in spite of the usual teaching that they are a common precursor of lung abscess, are but rarely so. Thus in 235 cases a foreign body was responsible in only three. The physical character of the embolus is thus clearly of great importance. Of final importance must be the fact that the embolic material is infected. In most cases the infecting organisms are those already present in the mouth, nose, or pharynx, and they determine the type of infection that supervenes.

The relative virulence of the pneumonitis that follows lodgement of the infected bronchial embolus depends in great part upon the virulence of the invading organisms and the level of resistance of the host. It is probable that a massive bronchial embolism that produces a 'drowned' segment of lung also gives rise to a more serious lesion than a smaller embolism.

This explanation of the mechanism of production of lung abscess by bronchial embolism also allows for the development of a pneumonitis and consequent abscess due to other organisms than anaerobic putrefactive ones. Thus a streptococcal, staphylococcal, Friedlander, etc., abscess can arise, or one caused by a mixture of these and other organisms. It is characteristic of most cases of lung abscess that the invasion starts and remains for some time in one broncho-pulmonary segment or sub-segment, and, indeed, may never spread beyond it. This clearly implies that a favourable local mechanism is necessary for the development of lung abscess in most cases. An attack of acute lobar pneumonia or of a massive confluent broncho-pneumonia may be initiated by a similar process of bronchial embolism, but its development is

presumably less influenced by local mechanical factors and proceeds, as do other acute invasive infective processes, by direct extension and by invasion of lymphatics and blood vessels.

This thesis of the part played by bronchial embolism in the development of lung infections is of fundamental importance and can, with advantage, be used to explain the varying behaviour that is observed with organisms of different types Thus the acute staphylococcal lung abscess that is considered in Chapter V probably starts in this way, but its development may be influenced by the invasive nature of the staphylococcus which favours dissemination within the lung with the formation of numerous secondary foci, and invasion of the blood stream with septicaemia or pyaemia.

Morbid anatomy

The pathological processes leading to the formation of segmental pneumonitis and subsequent abscess formation having been discussed, it is necessary to consider the morbid anatomical changes that develop.

(*a*) *Acute lung abscess with formation of a slough*

[illegible]

portion of lung involved, either pyramidal, cuboidal, or polygonal in shape, becomes consolidated (Figure 11*a*), and within a short time (certainly in most cases in less than ten days and in severe cases probably three to four days) gangrene occurs The visceral pleura and a thin layer of subjacent lung usually survive owing to the independent blood supply they receive from the sub-pleural vascular plexus (Figure 11*b*). In the most severe cases the gangrene may affect almost the whole of the pneumonic portion, including the pleura, and early intrapleural rupture occurs (Figure 11*c*) Occasionally smaller multifocal areas of gangrene occur, and several cavities are formed which may intercommunicate and may later coalesce (Figure 11*d*).

Before the morbid anatomy of lung abscess was studied carefully it was usual to speak of 'peripheral' and 'central' or 'hilar' abscesses. This misconception, which still unfortunately exists, rests largely on the use of postero-anterior radiographs of the chest; the addition of a lateral radiograph will often demonstrate at once that the apparent central or hilar abscess is really peripheral

It is of particular importance to note that the segment or sub-segment of lung in which the abscess develops always extends out to the periphery of the lung so as to involve the pleura Neuhof and Touroff have performed a valuable service in stressing this fact. The significance is that, by the time the abscess cavity has formed the overlying pleura is *always adherent* The area

a b c d

FIG 11 Diagrams to show segmental pneumonitis and various stages of abscess formation

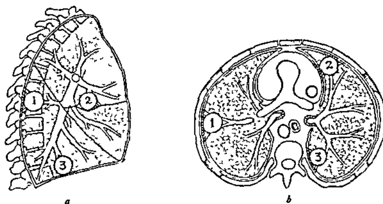


FIG 12. Diagrams to show the peripheral segmental nature of lung abscess The presentation may be costal (1), or it may be interlobar (2*a*), diaphragmatic (3*a*), mediastinal or paravertebral (2*b*, 3*b*).

of adherence may be small and, of course, may not be in relation to the costal pleura (Figure 12), but its presence is constant and it is of great practical surgical importance. Unfortunately, this early pleural adherence may not prevent later intrapleural leakage or rupture, either from extension of the primary abscess, or from its gross distension following blocked drainage. The presentation is most commonly on the costal pleura as this forms the largest portion of the surface of the lungs. The presentation may, however, be on the mediastinal or paravertebral aspect, the interlobar, or the diaphragmatic (Figure 12). Although the abscess may appear not to be peripherally placed, especially if it presents on an interlobar surface, it is imperative to appreciate that in all cases the presentation is *peripheral so far as the segment or the lobe is concerned* Moreover, the abscess cavity usually lies within less than a centimetre of the surface of presentation; even though an incorrect surgical approach may not uncover the most superficial area of presentation Neuhof and Touroff (1940*a*) report their experience of the primary situation of the abscess within the lobe as follows:

Superficial facing thoracic cage	67
[illegible]	3
[illegible]	2
[illegible]	1
Deep	0

My own experience in 117 operation cases is:

Superficial facing thoracic cage	103
Superficial facing fissures	6
Superficial facing diaphragm	1
Superficial facing mediastinum	2
Superficial facing vertebrae	5
Deep	0

Even when there is interlobar or diaphragmatic presentation there is often costal presentation as well (Figure 12*b*).

At this stage the intrabronchial communications are either totally occluded or are minute. This is shown clinically by the irritating nature of the cough which is largely unproductive; what sputum is raised is inoffensive and comes from the inflamed bronchi near the abscess. The occlusion of the bronchi is due to swelling, oedema, and tension. The first evidence of intrabronchial communication comes from a wave of foetor on coughing, experienced by the patient or noticed by the attendants; a little offensive sputum may also be raised. Presentation into the draining bronchi then occurs, either as a gradually increasing seepage with intermittent greater flow, or as a sudden massive emptying. It follows, however, that *in acute lung abscess in which a lung*

slough is present, adequate intrabronchial drainage cannot be established rapidly an effectively. The slough itself acts as a flapper-valve; as pus is emptied from th





Fig. 13 Fig 14

Fig. 13 Foetid lung abscess with slough There is widespread pneumonitis in addition to a terminal empyema
Fig 14 Acute foetid lung abscess to show slough extending out to involve the pleura; a large perforation has occurred and the patient died from drowning due to inhalation of the secondary pleural effusion.

cavity by coughing, the slough is flung up against the orifice of the draining bronchi and occludes them. In any case, their effective lumen remains greatly diminished by swelling and oedema Until the slough has been liquefied or broken down into sufficiently small fragments to be coughed up, the cavity cannot heal. In some, especially when the clot is not large, it is successfully liquefied and expelled, but in general the process is a horribly offensive and extravagantly dangerous one. In fact, unless there is positive evidence of rapid disintegration and extrusion of the slough, as shown by smooth and steady clinical resolution, the process should be terminated by operation. Almost all sound treatment is based on a consideration of the morbid anatomical changes present, and there can be but few better instances



Fig 15 Tomograph to show slough in a large chronic abscess cavity in the right upper lobe The slough could not be seen on a plain radiograph



Fig 16 Examples of lung sloughs removed from abscess cavities at operation

In these chronic cases, even when a lung slough is no longer present or has never existed, the purulent contents of the cavity are quite unfavourable

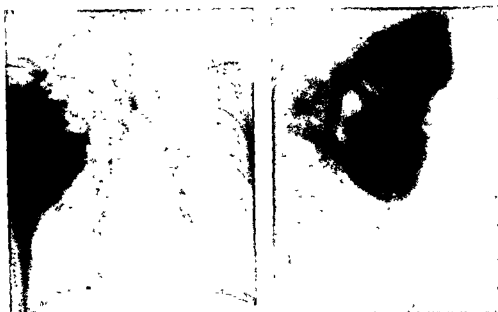


FIG 17 Acute foetid abscess of right upper lobe without slough formation, rapid healing followed external drainage at which the absence of any demonstrable slough was observed

for the establishment and maintenance of free intrabronchial drainage. The cavity contains thick, often horrible, pus and also a thick, semi-solid substance like soft putty or tooth-paste which can be evacuated at operation only by means of a spoon or by a very powerful sucker. This material blocks the bronchial orifices connected with the cavity, and is also clearly an ideal substance for further bronchial embolism.

Thus a characteristic feature of subacute or chronic lung abscess is *the formation of fresh abscesses* These may be in the walls of the main cavity where quite a number of small, secondary abscesses may be formed which open by pin-hole, or slightly larger, orifices into the main chamber or, more dangerously significant, present into adjacent, as yet unaffected, bronchi. In this way alone the process can creep and extend from one segment to another throughout the whole of a lobe or a lung (Figure 18) Alternatively or simultaneously, an entirely new abscess may be formed either in an adjacent segment or in another lobe, or even in the other lung, by a process that is best described as 'internal embolism.' What could be more favourable as emboli for the production of new acute foetid abscesses than the fragments of

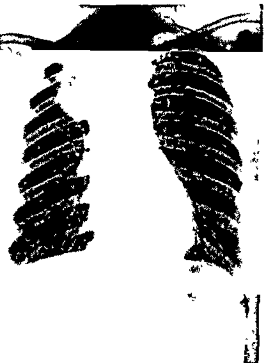
dead lung tissue or of the thick tooth-paste like material extruded from the parent abscess cavity; emboli that are both physically favourable and also heavily infected with organisms already demonstrably virulent to the host? The wonder is not that fresh abscesses occur, but that they do not occur earlier, more often, and in greater number in all cases.

Again we have an example of the value of an appreciation of the morbid anatomy underlying a disease process. So often the so-called exacerbations or 'relapses' that occur in the clinical course of a lung abscess are not intermittent phases of faulty drainage from the parent cavity, but are actually caused by *entirely new secondary abscesses.* This can usually be assessed with certainty from a radiographic study of the case providing careful anatomical localization is made of the affected segments, when it can be appreciated that in addition to the parent chronic cavity an entirely new acute abscess has appeared in an adjacent segment (Figure 19). Appreciation of this state of affairs must be the preliminary to any decision in regard to treatment that is to be logical and correct, for when by these two processes what was once a solitary abscess has extended to involve a whole lobe, or even a whole lung, recovery is unlikely with simple external drainage; lobectomy or pneumonec-



FIG 18 Total excavation of all segments of right upper lobe and middle lobe

tomy alone offer a prospect of relief. Touroff and Moolten (1935) rightly stress that, once established, the chronic phase of the disease never subsides spontaneously; 'the secondary changes in the lung parenchyma including the



a



b

Fig 19*a* Chronic abscess cavity in apical segment of right upper lobe The patient had been discharged as cured owing to general improvement and diminution of cough and sputum

Fig 19b The same patient as in 19a Return of illness, cough, and sputum is seen to be due to a new acute abscess in the anterior segment of the right upper lobe The apical abscess is still present Lobectomy was performed with complete recovery

bronchiectases may in time increase to such an extent that they completely overshadow the original abscess.'

In addition to the perils to life from local extension and local complications, there is always the danger of more remote dissemination, particularly to the brain. The mechanism of the spread of pulmonary suppuration to the central nervous system by means of the vertebral venous plexus is discussed and explained by Batson (1940) and also by Collis (1944).

and analysis of my experience in cases of lung abscess leads me to be unconvinced that it is correct. It is true that most foul-smelling abscesses constitute an entity; on the other hand, foul expectoration may occur in the course of some lung abscesses which undoubtedly do not conform to the usual type. Offensive sputum may be raised for only a short time during the early stages of the illness or the sputum may develop a foul smell after being inoffensive for weeks or months, presumably due to secondary infection and not indicating a primary foetid aetiology. It is by no means uncommon to find foul-smelling sputum in association with a bronchial carcinoma which is causing partial bronchial obstruction and thence secondary abscess formation; although anaerobes can flourish in these conditions of obstruction, the suppurative process is certainly not comparable with acute foetid abscess. The sputum may become foul in any broncho-pulmonary disease in which drainage of infected secretions becomes imperfect and anaerobes are able to grow in recesses or cavities that do not empty for long periods; this is one of the reasons why the sputum becomes foul in long-standing cases of bronchiectasis.

Yet again one must be careful in deciding that the sputum indeed is, or has been, genuinely foul It is not enough to rely upon an affirmative reply to a question as to whether it has been 'foul' or 'unpleasant'; to the patient any thick, purulent sputum may be foul or disgusting, or may taste unpleasant, and he may describe it as such although on closer inquiry he will admit that it did not actually smell foul Conversely, the patient may not notice that the sputum is foul-smelling, although this may be only too obvious to those in attendance. Smelling the breath on expiration or after coughing may reveal the foetid nature, but the most discerning assessment can usually be made at bronchoscopy when the characteristic odour may be recognized unequivocally.

It is often very difficult to assess whether, in a particular case, an abscess is or has been genuinely 'foetid' unless one actually smells the odour. The

the abscess

-malignant

cases studied during the last nine years, 162 (51 per cent) were classified as foetid and 156 (49 per cent) as non-foetid. These figures are not put forward as more than approximately accurate, the margin of error either way being possibly as much as 10 per cent. They do emphasize, however, that the typical and undoubted foetid abscess does not constitute anything like the majority of cases of lung abscess The figure of 51 per cent shows that reliance upon this feature in diagnosis would prove misleading in many instances. Neuhof and Wessler (1932) stated, 'clinically, abscess of the lung is practically synonymous with putrid abscess of the lung'; there can be no doubt that they would not support this statement to-day, but I quote it as illustrating an

incorrect attitude to lung abscess that still exists, but is quite unjustified in view of our present greater knowledge of the condition.

Classification

A satisfactory classification of lung abscess is difficult to achieve; the following is suggested as it covers what we know of anaerobic lung abscess to-day. It should need modification or amplification as we learn more of this condition.

Anaerobic Lung Abscess

1. *Primary*
   - (*a*) Acute pulmonary gangrene
     - bronchogenic
     - vascular embolism or thrombosis
   - (*b*) Foetid
     - Acute (acute foetid, solitary foetid, fuso-spirochaetal)
       - with slough
       - without slough of any size
     - Chronic
       - localized
       - diffuse
   - (*c*) Actinomycotic
     - acute
     - chronic
   - (*d*) Unidentified micro-organisms

2. *Secondary*

   Primary cause:
   - (*a*) Carcinoma,
   - (*b*) Adenoma,
   - (*c*) Intrabronchial foreign body, including broncholith,
   - (*d*) Intrapulmonary foreign body,
   - (*e*) Bronchiectasis,
   - (*f*) Lung cyst,
   - (*g*) Aerobic lung abscess: Staphylococcal,
     - Friedlander,
     - Streptococcal,
     - Tuberculous,
     - Unidentified or non-specific micro-organisms,
     - Infarct
       - systemic vein
       - endocarditis.

Primary Anaerobic (Foetid) Abscess

The most important group in this comprehensive classification is, without doubt, that described as 'acute foetid' for it includes a high proportion of cases of foul-smelling abscess in which the clinical and pathological picture is sufficiently precise to constitute a separate variety or entity. Of the various names (*acute foetid*, *acute putrid*, *solitary putrid*, *fuso-spirochaetal*) that have been suggested, the one that seems most satisfactory (or least unsatisfactory) is 'foetid' abscess and this name will be used henceforth in this book. The criteria of diagnosis of the condition will emerge from a consideration of the pathology and clinical course

Pathology

The condition is essentially an acute suppurative pneumonitis proceeding to a greater or lesser degree of gangrene and is characterized by a peculiar, penetrating, and exceedingly offensive smell. It is not the gangrenous lung that causes this smell, for examples of gangrene occur without the smell (e.g. Friedlander abscess as described in Chapter VI). The smell arises from an anaerobic infection, often mixed, which both causes the gangrene and flourishes on the dead tissue.

All gradations of gangrene occur, presumably due to variations in the resistance of the host and the virulence of the infecting organisms. In the extreme form suppuration is absent or minimal and the condition presents as an acute pulmonary gangrene; in fact, the term 'abscess' is scarcely applic- [illegible] proper to classify this condition [illegible]

a slough forms and rapidly separates to lie loose or partly loose in an abscess cavity distended with pus. Neuhof and Touroff (1942) have suggested that in this group a 'hyperacute' type can be usefully differentiated from an acute one. The gangrenous portion of lung that separates is usually of moderate size and corresponds to a sub-segment or even to a segment of lung; several smaller areas may, however, be affected, giving two, three, or more cavities closely situated in coalescent areas of necro-suppurative pneumonitis. Finally, in the least severe form the gangrenous element is small and the suppurative element preponderates; an abscess cavity is formed, full of stinking pus and containing a relatively insignificant and easily liquefied lung slough (Figure 19).

The process that gives rise to the abscess is suppuration and necrosis occurring in an area of segmental or sub-segmental pneumonitis; the primary event is, in almost all cases, bronchial embolism, and the mechanism by

which this acts was explained in Chapter II. The inhaled substance that forms the embolus carries with it anaerobic organisms (often mixed or symbiotic) of the type commonly found in the mouth or nasal passages. More rarely it is due to secondary anaerobic infection of a portion of lung infarcted by vascular embolism.

The progression to chronic anaerobic pneumonitis and the formation of new acute abscesses has also been described in Chapter II, and the gravity and hopeless prognosis of the established chronic condition has been emphasized

Of equally grave significance is the *early* occurrence of multiple foetid abscess formation, especially if a whole lobe is involved (Figure 20). Presumably these cases with early massive involvement are due either to gross contamination of the bronchial tree or invading organisms of high virulence or both. They might be more correctly described as diffuse anaerobic pneumonitis with secondary abscess formation and even classified as such, rather than be classified with acute 'solitary' foetid lung abscess

Bacteriology

According to Maxwell (1934), Leyden and Jaffe (1867) were the first to report the presence of spirilla in the foul sputum obtained from cases of bronchiectasis and lung abscess. The pathogenic role played by spirochaetes and fusiform bacilli in the production of foetid lung abscess is now generally accepted, but for many years it was argued that they were merely secondary invaders from the mouth The literature contains many good accounts of the bacteriological investigation of these abscesses, most noteworthy seem to be the contributions of Smith (1927, 1932); papers by Varney (1929), Crowe and Scarf (1928), Bucher (1936), and Stern (1935) should also be consulted In addition to the demonstration of spirochaetes and fusiform bacilli in a high proportion of these abscesses, Smith (1927) has produced lung abscess in laboratory animals by the introduction into the trachea and bronchi of material saturated with scrapings from human pyorrhoea pockets; Cohen (1922) has done the same Neuhof and Wessler (1932) sum the matter up by stating that certain pathogenic anaerobes are to be found in every stage of the infection and disappear when the infection subsides; they are the only pathogenic organisms found in putrid lung abscess which produce gangrenous lesions of the lungs experimentally when introduced into the bronchial tree

Burdon (1928) and Varney (1929) describe the finding of *Bact melaninogenicum*, which seems to possess significant characters. It produces a black pigment on suitable culture medium and the cultures develop a foul odour similar to that found in lung abscess. In symbiosis with other organisms it produces extensive necrosis of tissue. Varney states that the organism grows slowly in culture (two to three weeks) unless it is in symbiosis, when it grows

quickly. It forms granules which can be found in tonsillar crypts, some of the granules being so large that they might readily be aspirated during operation. The organism probably follows into the tissues where other micro-organisms such as spirochaetes, fusiform bacilli, and streptococci have caused initial damage; *Bact. melaninogenicum* lives on dead tissue and completes the process of destruction. Varney suggests that streptococci and other micro-organisms are of aid, not only because of their intense pathogenic powers, but also because of their ability to maintain the anaerobic conditions essential for other organisms.

It is probable that varied combinations of spirochaetes, fusiform bacilli, streptococci, and other micro-organisms can cause anaerobic or foetid lung abscess in favourable circumstances, and it may well be that other, as yet unrecognized organisms, particularly anaerobic streptococci, play a specific role at times Actinomyces certainly may do so and may be the only micro-organism found in some cases of foul lung abscess Actinomyces seems to have [illegible] the chest. At one end [illegible] prophyte and dies out quickly without any specific treatment once drainage is established or after the use of antibiotics; at the other end of the scale the infection it causes may be of a highly malignant invasive nature that may fail to respond even to intensive penicillin therapy. It can produce a lung abscess in every way comparable, clinically and radiologically, to the usual fuso-spirochaetal foetid abscess and can be isolated in almost pure culture from both sputum and discharge. It is, however, more likely to produce a necro-suppurative segmental pneumonitis with multiple small abscesses or foci of suppuration rather than a solitary abscess cavity. It may cause a non-foetid abscess.

Clinical Features

Acute pulmonary gangrene

Although it might be argued that this condition is not, strictly speaking, lung abscess, its relationship is sufficiently close to justify its inclusion and its description. It is a rare condition and rather than detail a formal account of its clinical features I record the following two cases that are the only ones I have encountered.

Case reports

1 Mrs. E N , aged 22, had been taken ill suddenly about a week before I was asked to see her She was then gravely ill with a rapid pulse and a temperature of nearly 104°; radiographs showed a large, probably distension, abscess cavity in the right upper lobe. There was no obvious primary cause. In view of the short duration of her illness it was decided not to operate, but 48 hours later her condition was even worse. She was continually coughing up large quantities of extremely foul, horribly offensive blackish sputum, clearly diagnostic of an acute pulmonary gangrene Radiographs showed that the whole right upper lobe was now opaque; operation was advised.

On November 8, 1938, under local analgesia a segment of the fourth rib in the mid-axilla was resected, the pleura was adherent. Incision of the lung revealed a large, gangrenous abscess cavity containing horrible, black, disintegrating tissue with much black oedema fluid; the cavity was packed open

The immediate effect of this operation was dramatic, the temperature fell abruptly to normal, the general condition improved, and cough and sputum abated. The pack was changed 48 hours later; two days later she had a sudden massive secondary haemorrhage and died at once.

It is probable that if chemotherapy had been available, especially penicillin, the process might have been controlled, but relief without operation would have been unlikely.

2 Mr J S, aged 25, underwent partial gastrectomy for a gastric ulcer under ether anaesthesia on January 31, 1941, the abdomen gave no trouble, but immediately after operation the temperature rose and signs appeared at the right base suggestive of atelectasis The temperature subsided after forty-eight hours but then rose again, and he coughed up sputum which was purulent and soon became offensive. He was given sulphapyridine A radiograph towards the end of February showed an opaque right base suggesting consolidation with some fluid, during the last week in February he was much better and the temperature was almost normal although there were still gross physical signs in the right lung. At the beginning of March he was not so well, and on March 3 (four weeks after operation) he coughed up ten ounces of foul sputum mixed with blood and then was afflicted with incessant coughing of dark frothy blood which was exceedingly offensive On March 7 the temperature rose to 103° and his condition became worse; radiographs still showed a large opacity at the right base, several aspirations of the chest revealed only a little blood-stained fluid

I saw him for the first time on March 9, i e in the sixth week after operation, he was gravely ill, pale (Hb under 60 per cent), sweating, and was incessantly coughing up stinking blood The whole clinical picture was characteristic of an acute pulmonary gangrene, the [illegible]

odour, and one large lung slough measuring 2 × 2 × 0 5 inches and other smaller sloughs.

There was immediate and dramatic relief from the incessant coughing, the gangrenous cavity was presenting into the oblique fissure, it was packed open Blood transfusion was given and sulphapyridine continued

His condition improved for several days and he suffered very little cough and sputum, but he became worse on March 14 and died on March 16, a week after operation There was no autopsy

It is just possible in this case that the gangrene was due to secondary anaerobic infection of an infarct, but this is not likely in view of the early onset of chest symptoms immediately after operation

Acute foetid lung abscess

Many of the clinical features emerge from what has already been said in the description of the pathology and morbid anatomy, and in order to avoid

too much repetition only a limited further account is needed. The primary cause is of considerable relevance to a clinical picture, but as Chapter VII is devoted to a detailed discussion of the primary cause of lung abscess in general, it must suffice now to say that in many cases of acute foetid abscess there is a history of a recent operation, usually on the mouth, nose, or pharynx. Dental extraction is especially important in this country; tonsillectomy is a common cause in the United States. Thus Flick, Clerf, Funk, and Farrell (1929) reported 172 cases of lung abscess, 97 of which followed tonsillectomy. In the absence of a recent operation the most common cause is dental sepsis, particularly chronic gum infection with pus pockets and tartar masses (Stern, 1935).

The incubation period is most easily assessed when the abscess follows an operation and it is then found that there is a latent period of ten to twenty days. This latent period often results in failure to appreciate the causal relationship between the preceding operation or tooth extraction and the development of the abscess. It is common to find the doctor, as well as the patient, fail to connect the lung illness with an episode that occurred, apparently uneventfully and successfully, one to three weeks earlier. The patient may even declare that it is an ill-fortune that has laid him low with an 'attack of pneumonia' when he did so well after his recent operation. Often he has made such an apparently successful recovery that he has been discharged home. He may also attribute his illness to 'catching cold' on the way home

Usually, however, inquiry reveals that all has not been completely well with the chest, even though it be merely a dry cough. The actual onset of the illness due to the abscess may be abrupt, and if it is accompanied by a sharp rise in temperature and shivering, and by a pleuritic pain in the chest, a diagnosis of a primary 'pneumonia' is made. It is often not until the onset of a productive cough with foul sputum that the correct diagnosis is thought of. Sputum at first is usually small in amount, mucoid and inoffensive, but the patient even at this time may complain of occasional nauseating waves of evil odour or of a little foul sputum. Classically, the emptying of the abscess is sudden, and within a short time many ounces of horribly offensive pus may be raised, often with blood as well. Occasionally life is endangered by the sudden rupture of a large abscess, especially in an elderly or debilitated patient, but more often the effect on him is one of consternation, alarm, and disgust. This sudden massive expectoration *is almost diagnostic of an acute* lung abscess, always bearing in mind, as was mentioned earlier, the need for considering and excluding expectoration of an empyema. Sudden rupture is by no means constant, and, indeed, it is common for the sputum to increase gradually both in amount and foulness with perhaps occasional blood-staining, and for the steady, foul expectoration to continue for days or weeks. The temperature to begin with is high, 103° to 104°, although it falls if free drainage is established or continues at a variable and irregular height if

drainage is unsatisfactory. The more severe toxic features and pyrexia may be lessened by chemotherapy or the antibiotics.

Pleuritic pain is common and may be associated with friction sounds, but other physical signs may be strikingly scanty or even absent. This is not surprising when one considers that the surface presentation of the affected broncho-pulmonary segment is in any case small, and may be in a quite inaccessible situation, hidden by the scapula, or paravertebral or interlobar in position. The physical signs of fluid in the pleura may be added, and if intrapleural rupture occurs the signs of air as well as fluid will be present. Rupture into the pleura is a disaster, the gravity of which is reflected in the patient's general condition; in severe cases he may be *in extremis*, and unless prompt relief is given, death may occur rapidly. Choking and suffocation from secondary intrabronchial flooding are often the actual cause.

Touroff and Moolten (1935), after pointing out the grave prognosis of the chronic phase of the disease, make the observation, 'on the other hand the mortality of the primary stage of typical lung abscess is exceedingly low. Death at this stage occurs usually only in markedly debilitated subjects, particularly in the presence of diabetes or senile cachexia' This is true, but it refers only to the primary stage of the abscess and its intrabronchial presentation, unless speedy recovery follows, the prognosis becomes progressively more serious.

In favourable cases of acute foetid abscess, in which a large slough is not present, once intrabronchial drainage has been established healing can be rapid. Pyrexia and other signs of toxaemia should subside while the sputum steadily diminishes in amount and loses its foul odour. Diminution of the sputum without corresponding clinical defervescence indicates that drainage has become inadequate One of the characteristic features of acute foetid abscess, however, is its relapsing nature; a process liable to occur even when no slough is present, but inevitable if the abscess contains a slough.

Neuhof and Touroff (1942) have also described what they call a 'hyperacute variety' of foetid lung abscess, and they state, 'the importance of segregating hyperacute cases lies in the necessity of regarding them as surgical emergencies irrespective of one's view in favour of or against early operation in the severe cases' They state that this variety has three additional radiological features.

1. Substantially more infiltration in the wall of the abscess than is seen in acute abscess
2. The abscess cavity may present an irregular or scalloped border due to attachment of gangrenous pulmonary sloughs to the walls.
3. The pleural reaction about the abscess often is both intense and extensive.

In all cases of lung abscess it is essential to have early and frequently-repeated radiographic control of the lung condition. Lateral radiographs as

well as postero-anterior ones are essential for a proper study and control of the lesion.

The whole question of the exact anatomical localization of the abscess is a large and important one and has been fully discussed in Chapter I.



Fig 20 Dense basal opacity due to a blocked abscess of the lower lobe with much surrounding 'pneumonitis' which obscures

The importance of radiographic control, which of course applies also to all forms of lung abscess, lies in the fact that it is and must always be the final deciding factor in a correct assessment of the patient's progress. Unfortunately, it is only too common to see apparently satisfactory clinical improvement, with temperature normal and sputum small in amount or absent, and yet radiography still shows that an abscess cavity persists. Until the abscess is completely healed, radiologically as well as clinically, the patient remains in peril of his lung and his life. It is by no means infrequent to see the patient who has been 'cured' of his lung abscess undergo a dangerous or fatal relapse. The radiographic diagnosis of a lung abscess depends, essentially, on the demonstration of a cavity containing air and fluid and surrounded by a greater or lesser amount of consolidation. In about half the cases of undoubted lung abscess it is, however, not possible to demonstrate such a cavity containing a fluid level, and, indeed, the more severely ill the patient the more likely is the fluid level to be absent In the most critical condition of all—namely, a *blocked cavity*—only a dense opacity will be seen (e.g. as in Figure 20), and the patient is often profoundly ill In such circumstances a diagnosis of 'pneumonia' may again be made with disastrous consequences to the patient. I would like to recall what was stated earlier in this book, that the diagnosis of an abscess depends on the expectoration of pus in quantities sufficient to have come from a cavity. Although at the moment of grave illness the amount of sputum raised may have diminished or fallen to a trace, the recent history of foul expectoration should tell its own story.

Case report

A R, a man aged 33, had developed an acute foetid abscess of the posterior segment of his right upper lobe some three months earlier and after a course of expectant treatment had been discharged as 'cured' Some two weeks before I was asked to see him he had been readmitted to hospital very ill, coughing up several ounces of offensive sputum a day, and still with a radiological abscess cavity in his right upper lobe (Figure 21*a*) External drainage was advised and arrangements made for his transfer to a chest unit, where he arrived the

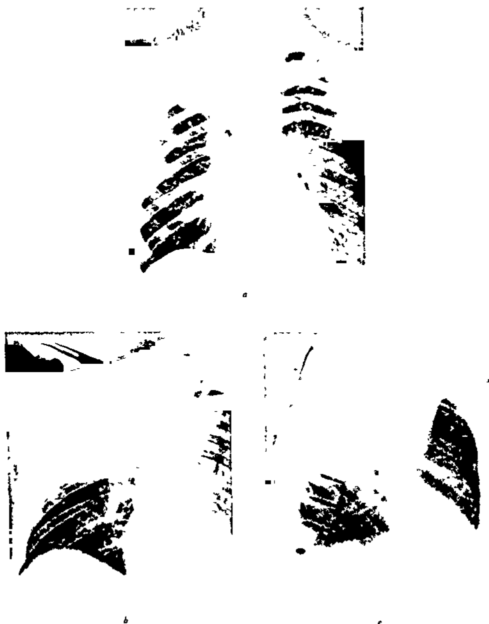


Fig 21 Chronic abscess of the posterior segment of the right upper lobe (*a*), which has undergone blockage and acute distension (*b* and *c*), an acute pneumonic process is simulated

following day When, on the succeeding day, I went to operate on him, I was greeted by my resident with the news that it was too late because the man was very gravely ill and now had an extensive pneumonic consolidation of the greater part of his right upper lobe. A radiograph did indeed show a dense opacity blotting out almost all the upper part of the right lung, and it was easy to understand how a diagnosis of pneumonia could be made (Figure 21*b*) On the other hand, it was quite certain that two days earlier the man had had an abscess cavity in the same site, because it had been shown radiographically, and he had been coughing many ounces of very foul sputum which had now decreased in amount It *was clear that he now had a blocked cavity and, far from being too ill* for operation, his grave condition made immediate operation imperative When the lung was exposed it was indeed found to be tense and distended, and incision revealed a huge, stinking abscess almost bursting with some ten to fifteen ounces of pus and lung sloughs

It is, therefore, very important to realize that a dense opacity in the presence of what is clinically a lung abscess is highly suggestive of an imperfectly-drained cavity and does not exclude cavitation.

*An abscess that is progressing favourably should show progressive radio*logical diminution in size and progressive clearing of the secondary pneumonic consolidation. In addition, it should remain empty, the demonstration of a persistent fluid level is usually in itself evidence that drainage is incomplete and therefore that all is not well. The significance of the persistence or development of a uniform opacity has just been stressed

The clearing of the surrounding opacity and the diminution in size of the cavity should continue and should be associated with correspondingly steady clinical improvement. Unless both *radiological* and *clinical* improvement continue, the course is not satisfactory. Clinical improvement without radiological improvement is likely to prove disappointing (Figure 19).

In contrast to early complete resolution, the illness may continue *with no* radiological improvement or even radiological deterioration. The more usual course is for an initial improvement to be followed by exacerbation and further remissions until a subacute or eventually chronic state of suppuration is present. The occurrence of frank abscesses in the walls of the parent abscess or the development of new abscesses in adjacent or distant segments has already been described.

Even though the abscess eventually clears radiologically, the damage done to the lung in the process of healing, especially if very prolonged, may be so great that permanent bronchiectatic changes and infection persist with all the attendant disadvantages and dangers to the patient.

In the chronic state *the patient usually runs a low fever*, with intermittent exacerbations, and continues wasted, pale, ill, and toxic; clubbing of the fingers develops and sputum continues to be raised in amounts that may be one to two ounces or may be as much as ten to fifteen ounces a day; it is usually persistently offensive, although this feature may vary *from time* to time. When the amount of sputum raised is large, a considerable part of it

may be clear, mucoid, and frothy, in contrast to the thick, purulent element. Haemoptyses may be small or may be large, frequent, and alarming.

The miserable condition of such a patient is pathetic, but it should be remembered that a chronic abscess that persists with but little clinical illness and small amounts of sputum may still prove to be just as dangerous as the more distressing type. Touroff and Moolten (1935) rightly state that in the chronic case the average duration of life in adults is less than three years; the hopeless prognosis, in fact, parallels that of cancer.

Secondary Foetid Abscess

The chief interest and importance of this group lie in differential diagnosis and in this respect the significance of offensive sputum was fully discussed in the opening portion of this essay. The first fact to bear in mind is that just because a patient is coughing up offensive sputum from an abscess, it does not follow that the condition is a primary anaerobic abscess with a lung slough

The antecedent history is of chief importance; a recent operation, especially on the nose, pharynx, or mouth, followed by an illness in which foul sputum soon appears, or the demonstration of chronic dental sepsis with tartar [illegible] l expectoration, afford [illegible] anaerobic abscess. A [illegible] ifected with anaerobes and thus associated with offensive sputum is given in the classification on page 27.

In most of these the history is lengthy and in many of them the sputum raised in the early part of the illness will not have been offensive. This is especially likely to be so in the case of primary aerobic abscess due to a specific organism, e.g. a streptococcus, in which chronicity has been accompanied by fibrosis, residual cavitation, and secondary bronchiectasis, and then the super-added anaerobic organisms.

Among the specific organisms the tubercle bacillus introduces difficulties and complexities. Most observers, like myself, must have met examples of acute lung abscess progressing to chronicity and with abundant foul sputum which are found to be associated with tuberculosis. The term 'associated with' is used deliberately because it is often difficult to be sure whether the tuberculous element is primary or secondary. It would seem that in some cases a septic process disrupts a tuberculous focus in the lung, either active or quiescent, and secondary tuberculosis results. Clearly this is not an unlikely happening considering the frequency of tuberculous foci The debilitating effect of the sepsis must also play a part in reducing the resistance of the patient to tuberculosis. On the other hand, cases occur in which the tuber-

culosis was without question the primary event; I have, for instance, had two examples which developed in patients who had been under treatment, including artificial pneumothorax, for several years for phthisis. In both of these a foul-smelling anaerobic abscess developed. In both the amount of sputum was very large, fifteen to twenty ounces a day, and this has been so in other cases I have seen in which the tuberculosis did not present as a primary condition. It is often difficult to find tubercle when the amount of sputum is large, for the great quantity seems, as it were, to swamp the tubercle bacilli. In one of these two cases mentioned above the sputum was consistently negative over a period of many weeks although very careful search was made and it was known to have been positive earlier. The patient had some fifteen ounces of sputum a day; pneumonectomy was performed and the volume dropped at once to about a drachm a day, which significantly was found to be T.B. positive within forty-eight hours of operation. It is safer to suspect tuberculosis as an accompanying element in any case of chronic lung suppuration associated with large quantities of sputum, and to make diligent and repeated search for acid-fast bacilli.

Infected *lung cyst* may mimic a foetid lung abscess very closely, for it is common for the infection to be anaerobic, fuso-spirochaetal, and very offensive. This is quite apart from an old chronic lung abscess cavity which has become epithelialized and mimics a congenital cyst.

In *bronchiectasis* it is well known that the sputum may become foetid, and in the course of the illness a secondary acute foetid abscess may develop, either in the affected lobe or elsewhere. The correct diagnosis should present no difficulty

A foul-smelling abscess may develop around a retained *intrapulmonary foreign body*, but again there should be no difficulty in diagnosis.

Intrabronchial foreign body may, of course, be more obscure and misdiagnosis frequently occurs; often there is no true foetid lung abscess but rather a condition of obstructive septic broncho-pneumonia with secondary foetid bronchiectasis.

Bronchial carcinoma or bronchial adenoma as a primary cause of offensive lung suppuration is very often overlooked, particularly when it presents as a frank cavity with a fluid level. A little forethought and careful investigation should, however, lead to recognition of the growth in most cases, although in some, more especially in younger patients, it remains impossible to confirm or exclude a growth until operation or autopsy. The finding of an unsuspected growth continues to be an occasional surprise even in the practice of the most careful and experienced. Certainly a growth should be suspected in any patient over fifty years of age who has developed a lung abscess with no apparent primary cause such as dental sepsis or a recent operation.

All these conditions of secondary anaerobic suppuration with foul-smelling

sputum have one thing in common; namely, a cavity or cavities with non-resilient walls and partly obstructed so that drainage is imperfect and the contents remain stagnant and unchanged for many days Under these conditions secondary anaerobic infection is very common, and organisms, often of relatively low virulence, are able to settle and multiply and produce the evil-smelling sputum which may so closely mimic that produced in primary anaerobic lung abscess both acute and chronic.

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AEROBIC (NON-FOETID) LUNG ABSCESS

Definition

It has already been emphasized that lung abscess does not constitute an entity but is a clinico-pathological condition due to many different causes and processes. The significance of a foul smell has been fully discussed and it has been pointed out that this feature does not justify accepting cases with an offensive smell as constituting an entity, although it serves as a convenient criterion for a primary grouping. A group of cases of lung abscess remains not associated with a foul smell and these must now be considered. Once more it is necessary to recall the earlier remarks (p. 26) on the frequent difficulty of identifying or excluding the presence of the characteristic offensive smell.

It can be stated at once that this aerobic or non-foetid group does not constitute an entity; it is merely composed of those lung abscesses that are not offensive. Although the term 'aerobic' is used, it is not a strictly accurate one for not all anaerobic organisms cause offensive suppuration; thus actinomycotic abscess appears in both the foetid and non-foetid groups because although it usually produces a foul lung abscess it sometimes does not. It must be repeated that it is our duty and our task to try and separate this rather confused group into as many of its component parts as possible, for only in this way can treatment be rationalized and confidence engendered. It is merely a matter of convenience to make this primary separation into a foetid or anaerobic and a non-foetid or aerobic group. Touroff and Neuhof (1941) have written on 'the differentiation between acute putrid and non-putrid pulmonary abscess,' but perusal of their account leaves one with the impression that there is a danger of the reader, inexperienced or unfamiliar with the problem, accepting their non-putrid group as a practical entity. This separation of the non-foetid cases is merely a primary convenience of classification and has only a limited bearing on clinical course and treatment.

Touroff and Neuhof postulate that the division is of great value in treatment because the tendency of the non-foetid group is much more towards spontaneous resolution, that the same urgency for operation is not present, and that an expectant policy can be pursued for a longer time with less danger and more chance of success. Moreover, they go so far as to state that early operation is even undesirable in the non-foetid group and should be avoided. This is to a certain extent true in that some specific types of non-foetid lung abscess have a much greater tendency to develop towards spontaneous resolu-

tion, and the morbid anatomical process may be predominantly one of suppurative pneumonia with secondary abscess formation (the abscesses often being small, multiple, scattered, and constituting a relatively minor volume in the inflammatory process) in which external drainage at any rate is less precise and less satisfactory. It is, however, not my experience that spontaneous resolution with low morbidity and low mortality and without serious permanent secondary changes in the lungs is substantially more frequent in the group as a whole than in the foetid group. This is clearly shown in the accompanying analysis of 318 cases (excluding 74 due to growth) seen by me in the nine years 1942–50, which is based on a primary separation into a foetid and non-foetid group It is true that there is an appreciably higher rate of spontaneous resolution in the non-foetid group (47 per cent as opposed to 30 per cent) and a somewhat lower proportion of chronic cases (41 per cent as opposed to 62 per cent), but the differences are not sufficient to do more than indicate, in this series at any rate, that the non-foetid group tends to be somewhat less serious than the foetid group Non-foetid lung abscess still remains a serious condition in which death, delayed resolution, and chronicity play a large part

TABLE I

ANALYSIS OF 318 CASES OF LUNG ABSCESS (EXCLUDING 74 DUE TO GROWTH)

	Total	*Spontaneous resolution*	*Required operation*	*Chronic, no operation*	*Died*	*Died after operation*
Foetid	162	55 (34%)	79	20	8	15
Non-foetid	156	77 (50%)	44	24	11	8

Table I shows the proportion of foetid to non-foetid cases of lung abscess seen over a period of nine years (excluding 74 due to growth) The non-foetid group shows a somewhat less grave tendency than the foetid group

TABLE II

ANALYSIS TO SHOW BEHAVIOUR OF ACUTE ABSCESSES IN EACH GROUP

	Total	*Spontaneous resolution*	*Required operation*	*Died*	*Died after operation*
Acute foetid	61	37 (60%)	20	3	3
Acute non-foetid	81	56 (70%)	16	6	4

Table II compares the behaviour of acute foetid and non-foetid abscesses. A slight difference in favour of the non-foetid group is seen.

TABLE III

ANALYSIS TO SHOW BEHAVIOUR OF CHRONIC ABSCESSES IN EACH GROUP

	Total	*Incidence of chronicity*	*Spontaneous resolution*	*Required operation*	*Died*	*Died after operation*	*Continued chronicity*
Chronic foetid	101	62% of 162	18	58	5	12	20
Chronic non-foetid	75	48% of 156	23	27	5	4	20

Table III shows the incidence of chronic cases in the two groups and compares their behaviour There is still a slight preponderance in favour of the non-foetid group but *chronicity, operation, and death are still formidable.*

The figures do not support statements made by Neuhof (1940): 'In general, it may be said that suppurative broncho-pneumonia appears to be a self-limited disease and that spontaneous subsidence undoubtedly occurs in the great majority of cases,' and, 'whereas putrid abscess is commonly encountered as a subacute or chronic disease, when effective treatment has not been instituted in the acute stage, subacute or chronic aerobic abscess of the lung is rare regardless of the treatment during the acute stage. The reason is to be found in the fact that aerobic abscess of the lung usually subsides spontaneously or is fatal or perforates into the pleura.'

CLASSIFICATION

It will be accepted that it is incorrect to apply generalizations on clinical course and treatment to individual cases of non-foetid lung abscess when it is realized that this group is made up of a number and variety of different types of lung suppuration. The only logical way and the only practical way is to subdivide the group into as many sub-varieties as can be recognized. In later chapters, for instance, staphylococcal and Friedlander abscess are each described as separate entities These two are the most striking and the most satisfactory to differentiate in some contrast to the rather more difficult and less precise differentiation that must now be attempted.

AEROBIC LUNG ABSCESS

(Synonyms: non-foetid abscess, aputrid abscess, circumscribed suppurative pneumonia with abscess formation, suppurative pneumonia, suppurative pneumonitis, suppurative broncho-pneumonia, necro-suppurative broncho-pneumonia with abscess formation, influenzal abscess, idiopathic abscess.)

and radiographs in certain of their cases are easily recognizable, apart from bacteriological confirmation When this is realized it does much to explain the confusion in description of the clinical features, pathology, and treatment that is encountered in the literature of aerobic (non-foetid) pulmonary suppuration.

PATHOLOGY AND MORBID ANATOMY

Segmental abscess

Many cases of acute non-foetid lung abscess are almost identical with acute foetid lung abscess except for the absence of a foetid smell; they are typically segmental in origin and most of what has been said about the pathology of foetid lung abscess applies to them also, with the chief difference that a slough is not commonly found. The absence of a slough is, however, not constant, as is shown in the description of Friedlander abscess. I have operated on another case of lung abscess in which extensive lung sequestration was occurring without any malodour; unfortunately, in this case no specific organisms could be identified. Another case is described later in which a small lung slough was present in a non-foetid pneumococcal abscess.

Case report

Mrs G F, aged 53, developed a cough in March, 1945, productive of one ounce of inoffensive purulent sputum every morning, she also complained of weakness, anorexia, dyspnoea, and occasional pain The cough continued until her admission to Guy's Hospital in June, 1945, when radiographs of the chest showed two abscess cavities, each with a fluid level, in the lateral portion of the anterior segment of the right upper lobe Bronchoscopy was negative Cough and sputum continued unchanged in spite of postural drainage and [illegible] fever up to 100° By the beginning of July [illegible] cavity which

External drainage was performed on July 6, 1945, after resection of a segment of the fourth rib immediately behind the pectoral fold the pleura was found adherent and an abscess cavity was opened 0 25 cm from the surface and containing tapioca-like material which was sequestrated lung still imperfectly separated It could be broken down with the finger and pulled away with scarcely any bleeding, there was a little sero-purulent fluid. The abscess was quite inoffensive

Bacteriological examination of the contents revealed a *Staphylococcus albus* on culture; histologically the tissue was shown to be necrotic lung with no specific changes

She improved for a time after this operation but an opacity remained in the lung, and by September 22 low fever had returned and progressive necrosis could be seen in the walls of the abscess cavity Large inoffensive sloughs could be picked out, and these were reported as consisting of amorphous and necrotic material

Right pneumonectomy was performed on October 15, 1945, but she unfortunately suc- [illegible]

[illegible]

its origin Numerous bacteriological examinations gave no [illegible]

The fundamental process in the formation of a typical non-foetid abscess is, generally, a segmental pneumonitis due to bronchial embolism and proceeding to cavitation without, or very rarely with, formation of a slough. Although, for instance, it is far more common for an acute foetid abscess to follow dental extraction or tonsillectomy or to be caused by septic teeth, many examples of acute non-foetid abscess are caused in this way, strongly suggesting that the type of organism carried into the lung by the infected bronchial embolus determines the type of abscess that develops. The abscess cavity lies close to the pleural surface of the affected segment, just as it does in acute foetid abscess, and early pleural adhesion occurs, the presentation is always peripheral so far as the lobe is concerned even though it is sometimes on the interlobar, mediastinal, or diaphragmatic aspect. Early or late intrapleural rupture may also occur

There is no difficulty about these typical abscesses with a small zone of surrounding pneumonitis, especially when they follow a nasal, oral, or abdominal operation or some other obvious primary cause When the abscess cavity is not such a prominent feature, and especially when no obvious

usually a large slough In the comparable type of non-foetid abscess sloughing may occur, but more commonly a simple abscess cavity is formed. Even in acute foetid pneumonitis the abscess formation is not always extensive, confluent, or severe, cavitation may be smaller or scattered (Figure 11*a*). The same happens in acute non-foetid suppuration; the process may be less severe and produces a segmental suppurative pneumonitis in which the abscess cavity is smaller and forms a smaller proportion of the inflamed segment, or a number of smaller foci of suppuration may occur giving rise to a few scattered abscess cavities, perhaps a centimetre or so in diameter, that may or may not coalesce to form a larger cavity or cavities These abscess cavities may not be demonstrable radiographically, although a febrile illness with purulent sputum may indicate their presence and they can be demonstrated at operation or at autopsy. Sometimes the process is a stage less intense; the segmental pneumonitis is not severe enough to cause abscess cavities even of moderate or small size, at any rate not initially, a uniform opacity is seen radiographically, and clinically the absence of continued fever and of purulent sputum indicates that suppuration is not an important element. It must always be remembered, as was stressed earlier, that the absence of radiographic evidence of a cavity does not preclude its presence; in many cases 'pneumonitis' is diagnosed when fever, cough, and purulent sputum are

sufficient to infer the presence of an abscess cavity concealed *within the opaque* area, or so full of pus as to blend with its surroundings.

A non-suppurative segmental pneumonitis may resolve, although more commonly it proceeds to delayed resolution, organization, and fibrosis, the process being a low-grade chronic inflammation. Alternatively it may develop towards suppuration; small abscess cavities may appear intermingled with fibrosis and bronchiectasis. This varied course of non-foetid lung suppuration has given rise to a number of different descriptive terms, suppurative broncho-pneumonia, necro-suppurative broncho-pneumonia (Neuhof, 1940), chronic suppurative pneumonia (Scadding, 1936, 1938), circumscribed suppurative pneumonia, etc.

It has also led to emphasis on the pneumonic element rather than the abscess formation; thus Neuhof (1940) states that the abscess may be in the midst of and 'apparently an incidental part of an extensive necro-suppurative broncho-pneumonia.' Scadding (1936, 1938) writes, 'I believe that many of these cases should be considered primarily as cases of chronic suppurative pneumonia with abscess formation. The symptoms of the abscess dominate the clinical picture, if the case comes to autopsy the large abscess cavity which is by then likely to be present is apt to be named as the primary lesion and the chronic pneumonic changes around it described as secondary.' This would appear to be an argument that, in some cases, is likely to come to resemble the one about the priority of the chicken or the egg.

Also (Scadding) 'clearly, where the process of abscess formation is well advanced, it is reasonable to think of the case from the clinical and especially from the therapeutic point of view as one of lung abscess; but the realization that the process at work is essentially one of chronic suppurative and organizing pneumonia does much to render comprehensible the frequently puzzling behaviour of the so-called "lung abscess of unknown origin." '

To depict or interpret segmental lung suppuration as ranging from a relatively simple non-suppurative pneumonia at one extreme through varying grades of suppuration up to intense suppuration and large abscess cavity formation at the other extreme is no unreasonable hypothesis. The chief deciding factors in the character of the ultimate lesion will be the resistance of the patient to the particular organism and also the character of the invading organism Some organisms, e g. the pneumococcus, very rarely produce suppuration in the lung, the reaction they provoke being essentially a pneumonic one. A wide range of conditions can, therefore, be expected with varying admixtures of consolidation and cavitation. If cavitation predominates we can with assurance speak of 'lung abscess.' If pneumonitis predominates and abscess formation is small in amount and of secondary clinical importance, then we may please ourselves by describing it as 'pneumonitis with abscess formation.'

It is not irrelevant in this connection to reflect on the varied clinical, pathological, and morbid anatomical manifestations of pulmonary tuberculosis. This disease may range from an acute broncho-pneumonic process proceeding to caseation (i.e. abscess formation), through a broncho-pneumonic area with an associated cavity, or a large cavity with minimal surrounding pneumonitis, to varying grades of chronic cavity formation (i e. abscesses) or chronic pneumonitis with progressive fibrosis and secondary bronchiectasis Moreover, any one or more of these processes may be seen at one and the same time in one or both lungs of the same patient. Indeed, we know only too well how difficult it may be to decide from clinical and radiological features alone whether we are dealing with tuberculosis or chronic lung abscess or a

This analogy is ore confusing group of cases of non-foetid lung suppuration we have next to consider.

Non-segmental or atypical aerobic lung abscess, chronic segmental lung abscess, new abscesses

It is relatively easy to understand and explain lung abscess formation of segmental origin, especially when the abscess, or pneumonic process with abscess formation, remains confined to one segment or perhaps spreads to involve an adjacent segment. It is more difficult and confusing in those cases in which the segmental origin is either not precise or is uncertain, or the process has rapidly extended beyond the segmental boundaries, or has spread irregularly throughout one or both lungs. Some observers refuse to accept the primary segmental origin of certain types of case. The behaviour of pulmonary tuberculosis has just been referred to as an example of the varied response that may occur in the lungs during the course of an illness due to one micro-organism. We also see the same when we study cases of acute lung abscess of specific origin in such as those caused by staphylococci, *Bacillus friedländeri*, or streptococci, and it is often possible to observe that the radiological features and morbid anatomy vary considerably from case to case, and from time to time in individual cases. Thus there may be an initial area of consolidation, either sub-segmental, segmental, or massive, with no evidence of definite cavitation although one or more small cavities may develop later; or a well-circumscribed abscess cavity with a relatively small amount of surrounding pneumonitis may be present from the beginning Speedy spontaneous resolution may occur, or the process may spread locally or elsewhere in the lungs or may proceed to delayed resolution and

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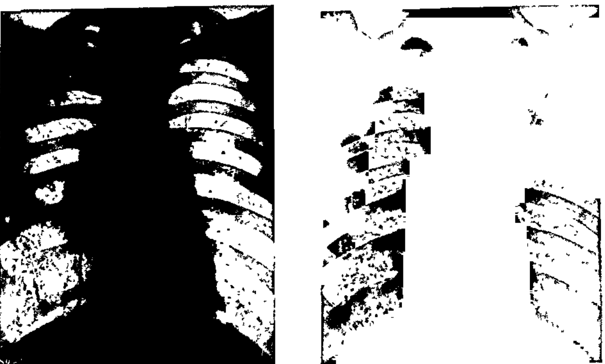
is this group that has led to so much difficulty and confusion and to so much

loose thought in lung abscess and in pulmonary suppuration in general. It is probable that the group covers a miscellany of conditions that should not all be considered together; but in our present state of knowledge to consider them together is the only way that seems to promise some sort of clarity in understanding, although later, as our knowledge increases, certain members will doubtless be separated off.

There is usually *a primary lesion in one lung which may be segmental* or may be irregular, and in which abscess formation occurs either as an overt or as a concealed state; the tendency is then to spread in the form of fresh areas of consolidation which may or may not break down into abscesses. The spread may be local by direct extension, or by sudden involvement of an adjacent sub-segment or segment, or it may be into another lobe or even into the other lung (Figure 22). Sometimes two, three, or more such foci, often in different stages of development, may be present at the same time. The original focus may resolve completely, and it may be one of the new foci that produces an abscess that needs drainage or proceeds to chronicity; a fact and feature clearly of great practical therapeutic significance. In the course of development of such a case we may, therefore, see either at one time or in succession what appears to be an area of non-suppurative pneumonitis, an area of suppurative pneumonitis with minor abscesses, and also an area of suppurative pneumonitis with frank, large, abscess formation.

Instead of the original focus or one of the secondary foci of pneumonitis remaining relatively small and confined substantially to a sub-segment or segment, it may spread to involve or overlap several segments or even progressively to involve a lobe or a considerable part of one lung, or even the whole lung. Here the process has certainly departed from a strictly segmental distribution even though it may have begun as a segmental pneumonitis consequent upon bronchial embolism (and my own belief is that this, in fact, is the usual mode of origin). This spread by direct extension, disregarding segmental boundaries, is just what happens in the spread of any non-suppurative broncho-pneumonia, or even in a true lobar pneumonia. It is also seen as a development of acute foetid lung abscess which has been allowed to develop unchecked Once more also a broad similarity to pulmonary tuberculosis must be recalled, from which at times the differential diagnosis may be very difficult.

In these cases of circumscribed or of spreading suppurative pneumonitis with abscess formation, the abscess cavities that form are not always peripherally situated, and especially if they are small, they may be 2–3 cm. from the pleural surface of the lung and hence pleural reaction may be slight and pleural adherence may be trivial or absent. In the spreading, diffuse, or chronic type, even though the abscess cavities may still be deeply situated,



a *b*

FIG 22*a* To show abscess in the right upper lobe and in the lateral region of the right lower lobe

FIG 22*b* The same patient as in Figure 22*a*, residual scarring and fine cavitation can still be seen in the right lung The left upper lobe now contains two abscesses, one is in the posterior part of the upper lobe, the other is in the lateral part of the anterior segment of the upper lobe

dense pleural obliteration is almost always seen (Figure 23). In the fully developed chronic state the condition of the lung is horrible to behold; a dense layer of thickened pleura envelops an organ that is completely airless and consists of chronically inflamed lung in varying stages of septic pneumonitis and fibrosis and with abscess cavities, some empty, some containing thick pus, dotted here and there, and often numerous, in addition, the bronchi are inflamed and irregularly bronchiectatic.

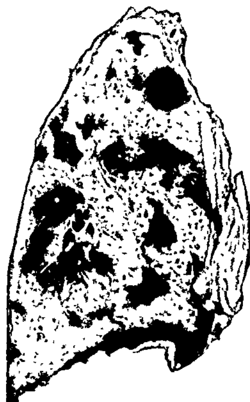


FIG 23 Diffuse septic pneumonitis with multiple abscess formation

The tendency to spread progressively and destructively, sometimes with resolution here and there, or scattered residual fibrosis, but all the time with an increasing amount of subacute or chronic suppurative pneumonitis with varying degrees of abscess formation, may be so marked as to tempt one to classify such cases as a separate variety of chronic suppurative pneumonitis. Sellors and his colleagues (1946) and others have written of this condition, but perusal of their reports fails to convince one that they are presenting a recognizable entity, but rather a mixture of varying forms of chronic suppurative pneumonitis with the one common feature of progressive spreading suppuration which usually leads to death if unchecked. Of the 27 cases described as an entity by Sellors and his colleagues the sputum was odourless in 6, but in the remainder the sputum was either foetid on admission or had been foetid earlier.

The course of a chronic non-foetid suppurative pneumonitis with abscess formation is liable to be just as serious as chronic foetid lung abscess when once it has been allowed to develop from the acute stage and has become established Secondary infection with anaerobes which cause the sputum to become offensive is also not uncommon.

Bacteriology

There is but little to add about the bacteriology of non-foetid lung abscess. The part played by the staphylococcus and by *Bacillus friedländeri* is dealt with later. Pure streptococcal abscess (including micro-aerophilic streptococci) is

also seen but seems to exhibit no specific clinical or pathological features; in the same way *B. influenziae* may sometimes be obtained in pure culture.

Although the clinical onset of lung abscess often resembles that of a specific pneumonia, and a diagnosis of pneumonia is often made, the pneumococcus is scarcely ever responsible. The course of a pneumococcal infection within the lung is towards inflammatory exudation without suppuration, even though suppuration so often occurs within the pleura. Very rarely cavity formation is noticed during the stage of resolution of a pneumococcal pneumonia, but this is usually a radiological and not a clinical observation and is unassociated with production of sputum; spontaneous and complete recovery follows within two to three weeks Kessel (1930) has applied the term 'aputrid pulmonary necrosis' [illegible] been applied by oth [illegible] and Gleich, Wu, anc [illegible] formation occurring in the resolution stage of pneumococcal pneumonia in which the abscess was either single or multiple or resembled widespread tuberculosis. They describe the condition as symptom-free abscess of the lung, not in communication with a bronchus and so not exposed to mixed infection, which heals rapidly. In typed cases of pneumococcal lobar pneumonia observed at autopsy, Cecil and Plummer (1932) noted lung abscesses in 5·8 per cent or 3 of 52 Type I cases, and in 7·6 per cent or 6 of 79 Type II cases In about half the instances the abscesses were multiple and minute. Chatard (1910) observed lung abscess in 1·4 per cent, or 9 of 658 cases; Lord (1925) in 0·4 per cent, or 2 of 500 cases; MacCordick (1931) in 1 of 525 cases; and Warr and Alperin (1933) in 0·4 per cent or 9 of 2,039 cases. In most of these reports it is not possible to determine the exact nature of the lesions referred to as lung abscess, but it seems clear that the incidence of abscess formation in pneumococcal pneumonia is very low.

Strep actinomyces commonly causes a foetid lung abscess or lung suppuration, but it is also sometimes responsible for non-foetid suppuration, especially when the pleura or chest wall is involved.

In many examples of non-foetid lung abscess no specific organisms can be identified; the flora is often mixed and changing In Scadding's cases the bacteriological findings were inconclusive, and there was no correlation between the clinical course and bacteriology. Many authors completely ignore or pay but scant attention to the bacteriology of their cases It may well be that our present methods of bacteriological examination are imperfect and that improved techniques, especially in obtaining uncontaminated material for examination, including actual tissue, will provide more information At present it seems that we must rest content with the fact that in a proportion of cases no specific organism or group of organisms seems responsible.

Clinical features

Typical acute segmental non-foetid lung abscess differs in few particulars from acute foetid lung abscess in its mode of onset and clinical course. If it follows a recognizable primary incident, such as an operation, the same latent interval of ten to twenty days is seen. Purulent sputum may be raised in gradually increasing amounts or classical sudden emptying of the abscess may occur; the only difference is that the sputum is not offensive.

In the less typical forms the illness may begin with pyrexia and general *malaise*, perhaps diagnosed as 'influenza,' and indeed many cases of specific type, such as staphylococcal or streptococcal, do occur as complications during a true influenza epidemic. In other cases the onset is associated with early chest symptoms, notably pleuritic pain, cough, and dyspnoea, and a diagnosis of 'pneumonia' is made until the production of purulent sputum suggests the correct diagnosis. In this 'pneumonic' group, and especially as a complication of true influenza in epidemic form, the illness may be profound and the patient prostrate; a septicaemia is often present, and in streptococcal cases the blood culture may be positive as well as in the staphylococcal cases described later. Extensive pneumonic consolidation may be present and other serious infective lesions elsewhere in the body such as pericarditis, meningitis, etc. In these circumstances the abscess is truly a minor element in a grave invasive illness, a fact that is stressed in the description of staphylococcal lung abscess (Chapter V). Reference should also be made to this chapter for a fuller account of the clinical features of the illness of staphylococcal lung infection which is also applicable to Friedlander and streptococcal pneumonia with abscess formation, and indeed to any of the severe primary lung infections with abscess formation.

The severity of the initial illness in this group is in marked contrast to the early phase of acute foetid lung abscess and of typical segmental non-foetid lung abscess. The early mortality is liable to be high, but to-day the response to chemotherapy and antibiotics offers correspondingly greater relief.

Unless death occurs in the earlier invasive phase, the tendency for spontaneous resolution of the abscess is somewhat greater than in acute foetid lung abscess, especially in the specific forms, and especially in staphylococcal lung abscess. In the mixed group of all cases of acute *non-foetid lung abscess* the slightly greater tendency to spontaneous resolution was seen in my own figures quoted earlier in which spontaneous resolution occurred in 37 of 61 cases (60 per cent) of acute foetid lung abscess and 56 of 81 acute non-foetid cases (56 per cent)

Delayed resolution, or non-resolution and chronicity, is also seen in non-foetid lung abscess, as was demonstrated earlier in the analysis of my figures (p. 41). Once established, the chronic suppurative pneumonitis that follows

carries the same grave ultimate prognosis as chronic foetid lung suppuration. Indeed, in chronic cases secondary anaerobic infection is often added, and the condition is virtually indistinguishable from a primary chronic foetid suppuration There is the same liability to death from secondary cerebral abscess or other pyaemic conditions.

Secondary Non-Foetid Lung Abscess

In general there is nothing to add to the remarks already made about secondary foetid lung abscess, for virtually the only difference is the absence of the offensive odour. Nothing, however, was said earlier about secondary lung abscess following infarction from septic thrombo-phlebitis or from infective endocarditis The notes of the following case are of interest in illustrating certain features of importance that indicate the difficulties in differential diagnosis that may occur, and also in that the case is one of an extremely rare condition; namely, secondary pneumococcal lung abscess.

Case report

Mrs M L, aged 43, was taken ill suddenly on December 12, 1944, with a rigor and vomiting, following pain in the right lower chest, a diagnosis of lobar pneumonia was made and *Strept. pneumoniae* was found in the sputum, and the same organism was also grown in pure culture from the blood She was gravely ill, but improved somewhat following a course of sulphathiazole A radiograph of the chest showed a right basal opacity and also consolidation with doubtful small abscess formation in the posterior segment of the right upper lobe. Dr Hoyle saw her on January 13, 1945, and found pus at the right base

On January [illegible]
was drained by [illegible]
January 27 no[illegible]
January 29 pus was found on needling in the second right intercostal space one inch from the sternum, the second costal cartilage was resected and it was then clear that the collection was within the lung, as pleural adhesions were thin and light it was considered safer to pack the wound and delay opening the abscess for a few days Another small empyema pocket at the right base containing two ounces of pus was found and drained It should be emphasized that she had very little cough and only a small amount of mucoid sputum

Pyrexia continued, and in spite of blood transfusion her condition continued to be very grave It had been decided to drain the small pectoral abscess on February 5, but on February 4 she was suddenly seized with severe pain in the back of the left thigh and became dyspnoeic and sw[illegible]
her painful, col[illegible]
femoral artery [illegible]
and some blood [illegible]
almost at once

Autopsy revealed a bicuspid aortic valve which was the seat of a malignant endocarditis, [illegible]

small empyema containing 5 ml. of pus lay against the vertebral column. The anterior

It should be noted that the lung abscess was not yet in communication with a bronchus and also, in spite of the fact that it contained a slough, it was not offensive

CHAPTER V

STAPHYLOCOCCAL LUNG ABSCESS

STAPHYLOCOCCAL lung abscess is a condition of great practical importance which is imperfectly understood and therefore infrequently diagnosed. It is almost a clinical entity and can often be diagnosed with confidence on clinical and radiological grounds before bacteriological confirmation is forthcoming. Its recognition is of great importance from the point of view of both prognosis and treatment It is a perfect example of acute primary pneumonia with abscess formation.

The literature on acute staphylococcal pneumonia is extensive and, indeed, somewhat bewildering. Much of it is repetitive and not a little of it is confused, and although many authors mention lung abscess as an accompaniment, its importance as a leading feature is rarely stressed. Until recently there was no clear and concise account of staphylococcal lung abscess as a separate clinical entity.

Staphylococcal infection of the lung may occur as a secondary, presumably blood-borne, infection from a focus elsewhere in the body such as an osteomyelitis, or a boil, carbuncle, or area of staphylococcal cellulitis. In addition, the organism may involve the lung as an apparent primary manifestation, and it is this type of staphylococcal pneumonia with abscess formation with which we are principally concerned in this chapter. The term 'apparent' primary manifestation is deliberately used because a study of these cases shows that the staphylococcal infection is often secondary to some other co-existing or pre-existing disease of the lung. For instance, it is liable to be a secondary complicating factor in 'influenza' when the way has already been prepared by the influenzal illness; again, it will be found that it not infrequently attacks a sufferer from asthma or chronic bronchitis. In this sense the staphylococcal infection may be secondary, but it is primary in the lungs so far as the body itself is concerned. The lung infection may then be followed by a general blood-stream invasion, a true staphylococcal fever, septicaemic or pyaemic, resulting. Clinically, in fact, one of the outstanding features of the illness, in the earlier stages at least, is the staphylococcal fever. The importance of 'staphylococcal fever' was described by Ryle (1930) in a lucid and scholarly article. He writes: 'How much less satisfactory would our understanding of typhoid fever and pneumonia be [illegible]

coccal infection becomes when we regard it, in common with typhoid and

pneumonia, as a septic fever.' This 'staphylococcal fever' is present in most cases of staphylococcal lung abscess; sometimes dominating the clinical picture if only for a short time, sometimes forming only a background. It must be recognized, both for diagnostic purposes and for understanding the natural history of the disease, but it should not be allowed to obscure certain features of the 'lung abscess' from our present point of view. It is the confusion between the general staphylococcal illness and the local manifestation that has led to such lack of clarity and precision in many of the writings on staphylococcal pneumonia. The general and local aspects of the disease are closely, indeed intimately, related; this fact must be appreciated, but an analysis of the two component parts or the relative importance of the two components in each individual case is necessary for proper description and proper understanding From his own account of staphylococcal fever Ryle does not appear to have appreciated the part that a primary staphylococcal pneumonia may play in the illness, as opposed to a secondary pyaemic involvement of the lungs; one of the cases cited by him (Case 6 in his series) would appear to be an example of primary staphylococcal pneumonia with lung abscess formation

Incidence and Mortality

The condition is not a common one although it may occur more often in the course of influenza epidemics, such as that of the winter of 1943-44. On the other hand, there is little doubt that appreciation of its characters would lead to more frequent diagnosis, quite a number of my own cases would have passed unrecognized unless one had been familiar with the condition. Heffron (1939) states that only 6 out of 3,319 cases of 'lobar' pneumonia were staphylococcal and 'it is not clear that this organism can cause true lobar pneumonia, and the lesion produced is usually of the broncho-pneumonic type.' Reimann's review of the literature (1933) suggests that 7-9 per cent of all 'atypical' pneumonias are due to the staphylococcus. Chickering and Park (1919) quote the general rarity by reference to about 800 cases of pneumonia in New York City treated at the hospital of the Rockefeller Institute in a period of five years from 1913-18; 13 were due to the staphylococcus, and 10 of these were fatal

My own series includes 39 cases, during the last nine years, during which I have kept a complete record of all cases of lung abscess seen (including those due to malignant disease) the incidence was 31 out of a total of 476 cases, i.e. roughly 7 per cent. If malignant abscesses are excluded the incidence is 31 out of 393 (8 per cent).

We owe thanks to Chickering and Park (1919) for one of the best accounts

which they saw 1,049 cases of pneumonia complicating influenza. They observed that one group of cases exhibited symptoms entirely different from the other pneumonia cases; they found that these were due to staphylococcal pneumonia. The numbers were relatively few as compared with the total number of cases of pneumonia, but large when correlated with the total number of deaths. Thus 385 of the 1,049 pneumonia patients died, but in 153 of these the staphylococcus was found. The actual number of staphylococcal cases, they say, may have been even higher. Only 2 patients with staphylococcal pneumonia survived.

The high mortality is stressed by most writers. The mortality in the Rockefeller series (10 out of 13) has already been mentioned. Cole (1927) records 13 deaths out of 19 cases; Bullowa (1937) 15 out of 27; and various other authors record a similar high mortality in small series of cases. Heffron (1939) states that the published figures in infants and children show a variation in mortality between 25 per cent and 80 per cent. It is dangerous to draw general conclusions from most of these small series, and especially from a series recorded in any one year or any one epidemic as so much depends upon the special circumstances of the time and, not least, on the virulence of the particular invading organism. In my own series, which extends over seventeen years, and, therefore, before the introduction of chemotherapy and the antibiotics, 6 out of 39 patients (15 per cent) died. There have been no deaths since 1942, since when 24 cases have been seen. The condition need not, therefore, carry a high mortality. This is recognized by MacKeith (1941), who states that in addition to the fulminating type there is a benign type of low fatality and adds that although the longer series of cases reported do not differentiate between these two groups in giving figures, a study of reported cases shows these two groups clearly. In any case, the advent of the sulpha drugs and of penicillin must cause a complete revision of all our earlier views and experiences on mortality.

Clinical Features

Attention has already been drawn to the advantage of trying to separate the two component parts of the clinical features of the disease; namely, the 'staphylococcal fever' and the lung abscess itself. In some cases this differentiation may be difficult, impossible, or even artificial; at times the features of a general, almost overwhelming, infection are predominant; in others the features of lung abscess are chiefly manifest. For clarity and for ease in description they are, however, conveniently considered separately.

For a description of acute staphylococcal pneumonia with staphylococcal fever one can do no better than refer to the description given by Chickering and Park (1919). It is, however, necessary to realize that they were dealing

with a particularly virulent type of the disease, and for this reason the mor fulminating features of the picture as they saw it should be modified to mee the less severe case that one is more likely to meet apart from during a majo epidemic. The virulence of the disease in their series is shown by the rapi course and early death; thus 12 of their 153 patients died in the first five day of the illness and 73 between the fifth and tenth days, making a total of 8 deaths or 55·5 per cent in the first ten days. 'These patients were extremel prostrated almost from the onset of their infection. After being ill from thre to four days with influenza their condition became critical. They exhibited a unusual type of cyanosis The cherry-red and indigo-blue colour was, indeed very striking, though not pathognomonic of the condition.' They observ that 'the onset is almost always insidious and rarely accompanied by the chil and localized pain of a typical lobar pneumonia, though the course of the disease is extremely rapid The facies, the anxious expression, and deep cyanosis suggest a grave prognosis from the onset, at a period when physical signs of pulmonary involvement are but scanty. Herpetic eruptions on the lips are scarcely ever noted, nor is delirium present except rarely. Usually the mind is clear almost to the end. Epistaxis is not uncommon. Occasionally pleuritic pain is complained of, but this is not usual. It is the picture of a general septicaemia, so often seen in puerperal sepsis when the patient so little realizes the close proximity of death.' It is abundantly clear that Chickering and Park were dealing with an invasive illness of exceptionally high virulence, the more striking features of which require to be modified to some extent. They go on to say that 'sweating is not a striking symptom of this type of infection, though near the end the skin frequently becomes moist and later clammy.' This has not been my experience which has been more in accordance with Ryle's (1930) observation: 'I should like to emphasize the frequency and diagnostic significance of sweats in staphylococcal fever, whether due to a focal or general infection. After tuberculosis and infective endocarditis it should be regarded as one of the most important of the "sweating" fevers' Ryle and Chickering and Park agree, however, about the pulse-rate. Ryle states: 'The pulse in staphylococcal fever is frequently slow in proportion to the temperature.' Chickering and Park say: 'The pulse is relatively slow, at the onset under 100, and in only a few cases did it rise above 120 until just before death. The quality of the pulse, on the other hand, is usually poor, small, weak, and in many cases almost imperceptible.' With these observations I fully agree and have sometimes found the relative lowness of the pulse-rate a helpful diagnostic feature (e.g. Case 2, page 65). A high pulse-rate or a sudden rise should suggest a complication such as pericarditis, pneumothorax, or large pleural effusion. The fever on the whole is high, ranging between 104° and 105°, with frequent remissions to 101°. Rigors are unusual but do occur. Several of my cases have begun with

pleuritic pain. 'Respirations usually range between 24 and 36, and in some cases rise to 50 or 60 without much obvious discomfort. These patients rarely have the painful laboured breathing seen in pneumococcal infections'

The lung abscess element in the clinical picture must rest upon the production of sputum in greater or lesser amount. During the acute pneumonic phase sputum will be raised but will be small in amount and typically purulent with varying degrees of colouring from blood, amounting at times to frank red blood Chickering and Park state: 'The most characteristic feature of this type of pneumonia is the sputum When typical, the sputum is friable, purulent material of a dirty salmon-pink, resembling anchovy sauce or the contents of an over-ripe furuncle. Occasionally the sputum is haemorrhagic, at first suggesting an acute pulmonary haemorrhage; but on close inspection its purulent character can be distinguished and one can almost give a fatal prognosis when sputum as described above is obtained.' Here it should again be noted that the authors are describing what is clearly an unusually virulent type of disease, but this has not been appreciated by some writers who have repeated the statement that a very characteristic feature of the sputum in staphylococcal lung abscess is that it is pink, like anchovy sauce It has not been my experience that this is common, more often—i e. in the less fulminant albeit severe type—the sputum is merely purulent. Chickering and Park themselves say 'typical sputum, however, cannot always be procured, and frequently cases that ultimately result fatally produce only greenish yellow purulent material which on culture yields the staphylococcus as the predominant organism' In the hyperacute, haemorrhagic type they state that a smear of the sputum shows field after field of Gram-positive cocci in clusters.

This again one can confirm; in some cases a pure growth of *Staphylococcus aureus* is obtained from the sputum, especially early in the illness. Later, and in less acute types of abscess, the staphylococcus is only one of a mixture of organisms. In such cases the proof of its major guilt may rest chiefly on analogy from the clinical and radiological features, but in some the proof can be obtained by blood culture, an investigation that should always be made in a suspected case (see Case 2, page 65) I have had one patient with typical staphylococcal lung abscesses with staphylococci in the sputum, in whom blood culture revealed a streptococcus. This combined infection is mentioned by several authors as occurring at times.

The sputum is in general odourless, but in some of my cases it has been said to be offensive, although never having the horrible penetrating odour of the typical acute foetid lung abscess due to mixed infection with anaerobes. The amount of sputum commonly increases steadily from the beginning of the illness, that is, from the pneumonic phase to the abscess phase, although the sudden expectoration of a large quantity may indicate the evacuation of

an abscess cavity. The amount expectorated may reach five to ten ounces and may continue at this level for several weeks.

The physical signs in the chest vary; they may be unilateral or bilateral, unilobar or multilobar. Most often they point to a broncho-pneumonic process, although confluence may suggest a lobar type of pneumonia. Pleural involvement is not uncommon and friction sounds are heard; fluid, clear or purulent, also appears and several of my patients came for the resulting empyema.

Another, and at times strikingly dramatic, result of pleural involvement is the occurrence of a spontaneous pneumothorax which may even become a tension pneumothorax and be the cause of death if unrelieved. This is more common in infants (see Case 8, page 85), and the staphylococcal basis of such an occurrence must always be thought of in their case. It is a peculiar fact that this rupture into the pleura can occur and yet infection and fluid formation may not follow At post-mortem the ruptured abscess or cluster of abscesses can be seen on the surface of the lung, not unlike a group of small boils. Collis and Foster-Carter (1940) describe a case in an infant of 8 weeks in whom a thoracotomy was performed for the tension pneumothorax and the small ruptured abscess was identified; the patient died. Lund (1945) describes an example of spontaneous pneumothorax and staphylococcal empyema in a child of 18 days in which recovery followed drainage of the pleura by an intercostal catheter In certain of these cases, as will be shown later, the condition is not a pneumothorax at all, but a bullous distension of the lung, and indeed it is not at all clear from their description of the autopsy that this was not so in Collis and Foster-Carter's case. The recognition is of great practical importance for, as will again be shown later, the treatment is essentially non-surgical even when a tension pyo-pneumothorax would appear to be present. I have several times been asked to operate on such infants, and the notes of two, both of whom have made a complete recovery after conservative treatment, are given later (Cases 6 and 7, pages 74 and 77).

The phase of high fever may last for several weeks, even eight to ten (see Case 3, page 69), or did so in the days before penicillin; or the fever may lessen or subside completely and then recur, due to the occurrence of fresh areas of pneumonia and abscess formation. Typically, however, the acute phase of staphylococcal pneumonia passes gradually into the phase of staphylococcal lung abscess with irregular rises in temperature and variations in the amount of sputum. The condition may become chronic (e.g. Case 4, page 71), and with the staphylococcus overgrown by other organisms in the sputum and the typical form of the early acute illness not appreciated or not known, the diagnosis may be very difficult. In some (e.g. Case 7, page 77) the presence of a large abscess cavity and abundant sputum may lead to an incorrect diagnosis of an empyema that is being coughed up

Finally, staphylococcal lung abscess may at times be ushered in by a short illness in which none of the features of a specific staphylococcal pneumonia is seen. If a solitary abscess results, the differential diagnosis from any other type of lung abscess may easily be overlooked.

Morbid Anatomy

It would be more logical to follow an account of the clinical features with the radiological appearances, but as a proper understanding of these depends upon a knowledge of the morbid anatomy this will be described first.

In the metastatic form of pyaemic staphylococcal invasion of the lung the foci are undoubtedly blood-borne, but it should be appreciated that in the primary pneumonic type with abscess formation the infection is by inhalation just as in many other types of pneumonia. The distribution is of broncho-pneumonic type, although the lesions may be so confluent as to involve the greater part of a lobe (Figure 27*a*) or even a whole lung (see Figure 24*a*); they may also be bilateral or multilobar.

At first the lung is very congested, and in the hyperacute type is intensely haemorrhagic with the cut surface like the cut surface of the spleen. The characteristic feature is the rapid appearance of many foci of suppuration, at first pin-point in size, but soon enlarging sufficiently to be accorded the dignity of 'abscesses.' The whole appearance is in keeping with the intense reaction and multifocal suppuration that one is familiar with in staphylococcal infections of the skin and subcutaneous tissues. As the condition progresses the small abscesses become confluent and ultimately abscess cavities of varying size are formed containing thick yellow staphylococcal pus. These are mostly at the periphery of the lung, under the pleura; a factor responsible for the pleural complications mentioned above. They may also be present throughout the whole substance of the lung. It is significant that Chickering and Park state that 'of cases not showing abscess formation, three were very early, the patients dying on the fourth, sixth, and seventh days.' In one of Reimann's cases a large abscess was present after an illness lasting five days. This rapid formation of an abscess from a staphylococcal infection is again not surprising when one remembers the course of a staphylococcal infection elsewhere in the body, when pus can be formed very quickly. There is, however, another process responsible for the formation of a 'large abscess cavity,' and that is production of a distension cavity owing to communication with a bronchus. The bronchogenic origin of the infection has already been mentioned and the relation of the abscesses to the bronchi in the broncho-pneumonic areas is intimate. As soon as evacuation into a bronchus occurs the soft friable walls of the abscess are exposed to the bronchial air stream; distension can then easily occur either by a one-way valvular mechanism or

more suddenly by the force exerted by coughing. The recognition of this mechanism of the production of a cavity in the lung in pulmonary tuberculosis is now so wide that it seems unnecessary to elaborate it. It is sufficient to stress that the presence of a large cavity in the lung in staphylococcal infection does not necessarily, or even commonly, indicate that gross lung destruction has occurred. The condition is, therefore, largely recoverable, and that this is so can be seen from Figures 26, 28, and 29. This observation would seem to be of fundamental importance in considering the management and treatment of these cases As will be shown in the next section, the radiological appearances of the abscesses are commonly those typical of a distension type of cavity.

The formation and enlargement of cavities by this rupture into a bronchus and distension by the air stream may take place simultaneously in several places at once (Figures 27 and 28), and even gives rise to huge bullous-like cystic spaces under so much tension that the adjacent lung which contains them is rendered completely airless.

Radiological Features

In the earliest stages the lungs show small woolly opaque areas which may be scattered throughout both lungs or may be confined to one lung or even to one lobe. The opacities become larger and more dense, presumably as the area of initial broncho-pneumonia proceeds to suppuration and coalescence. Soon one or more rounded opacities of varying size appear which are due to frank abscess formation, although as yet unruptured and containing no air. These areas may become confluent so that apparent massive consolidation of a lobe (Figure 27*a*) or of a whole lung (Figure 24*a*) is present. Next the opaque areas reveal their true abscess nature by the appearance of a fluid and air-containing cavity, often of giant size (Figures 26*a* and 27*b*). Several of these may be present, perhaps in both lungs (Figure 27), and when characteristically empty or almost empty a massive soap-bubble appearance is given (Figures 27*c* and 28*c*). Bronchogenic spread may occur, and, therefore, while in one part of the lungs mature distension abscesses may be seen, in other parts early soft woolly opacities or denser mature areas of suppuration can be recognized. In other words, all stages of the process may be visible on one radiograph. The condition need not be multifocal; a solitary abscess of characteristic type can be seen (Figure 26*a*).

The condition of the lung surrounding the abscess cavity varies considerably and with the phase of the disease. The abscess may indeed lie, almost obscured, in a massive opacity (Figures 24*a* and 29*a*); in others a less massive but still considerable opacity surrounds it (Figure 27*a*); again, the surrounding opacity may be thin and discreet, and finally the wall may be almost linear

radiologically and the thin-walled, soap-bubble abscess lies in almost normal-looking lung tissue (Figure 27*c*). It is this appearance in particular that supports the contention that the cavity is maintained in its distended state by the air stream and not solely by destruction of lung tissue. The cavity may be completely empty or may contain a very small fluid level, again suggesting a distension phenomenon The subsidence or resolution of active inflammation is shown by disappearance of the opacities, but cavitation of variable size may be demonstrable radiologically for weeks or months. This ranges from fine honeycombing to larger spaces resembling emphysematous bullae (Figure 24*b*). At this time, also, evidence of scarring appears (Figures 24*b* and 26*c*). The lung may resolve apparently completely (Figure 29*e*) or radiological evidence of permanent damage remains This usually takes the form of fine scarring, alternating with emphysema, or honeycombing with some mediastinal displacement (Figure 24*c*) In five cases a large bullous-like air space remains (e g Figure 25*a*) in which the resemblance to a congenital cyst of the lung is close

There can be no doubt that congenital cystic disease may be diagnosed on too slender evidence and on presumption only The patient whose radiographs are shown in Figure 25 was an undoubted example of acute staphylococcal pneumonia with abscess formation. He was a boy aged 17 who had two separate empyemata drained on the left side and one lung abscess in the right upper lobe. A pure growth of *Staphylococcus aureus* was consistently obtained from the pus. The distension cyst in the right upper lobe has persisted and has been reported radiologically as a congenital cyst, which it scarcely can be.

It was pointed out earlier that staphylococcal abscess not infrequently affects a patient already suffering from lung disease such as chronic bronchitis, emphysema, or asthma. In such a case it is not surprising if the lung is unable to recover so completely from the damage inflicted on it, and gross bullous formation is more likely to remain This was so in two of my patients, both old, asthmatic, and bronchitic, who were left with a large thin-walled bulla at the site of an abscess in the left upper lobe.

Bronchographic examination may be of great interest and very revealing. In some cases in which extensive bilateral disease has been present the bronchi seem to have suffered little or no residual damage (Figure 27*d*). In others, bronchiectasis can be demonstrated at the site of the original abscess; the

The necrosis of the bronchial walls is easily demonstrable histologically in the acute phase of the disease and has been recorded by many observers.

When the lungs are involved in the pyaemic type, multiple small woolly opacities are seen which are quickly replaced by small, empty, abscess cavities. Sometimes one or more of these may distend to a moderate size and less often to considerable size; an excellent example of such a case is shown in a radiograph in an early paper by Florey and Florey (1943) on the treatment of staphylococcal septicaemia with penicillin. Their patient recovered. Radiologically the lung in these cases may recover completely.

Although pathologically the condition of secondary or pyaemic lung abscess has to be differentiated from the primary form, the clinical and radiological presentation in the lungs may be identical in the two types. In the pyaemic type the abscesses are characteristically small, multiple, and bilateral, but only one abscess may be seen in an undoubted pyaemic case, and many bilateral ones may occur in a patient with a primary lung infection. Also the abscess or abscesses in the pyaemic type may distend to a large size to give the characteristic thin-walled empty, or almost empty, space with minimal surrounding consolidation. This has been so in two of my cases; in one the primary focus was a vein infected after blood transfusion, in the other an acute mastoiditis In each case the patient was presented to me as a case of lung abscess' pure and simple, the secondary nature and secondary importance of the lung lesion not having been appreciated.

Personal Cases

Case 1

In 1933 I was asked to see a man aged 45 in the wards of Guy's Hospital who was gravely ill with a lung abscess He had been ill for seventeen days and was having frequent rigors with temperature rising to 104° and 105° He was coughing up several ounces of thick purulent sputum a d[illegible] middle lobe, [illegible] scopy had b[illegible] illness which [illegible] seen coming [illegible] this case over the same evening, it occurred to me that the abscess cavity could not be the true cause of such a serious illness since it was well-drained and contained only a trace of pus The man died three days later, and post-mortem examination revealed staphylococcal pyaemic abscesses in the heart muscle and kidneys, the walls of the abscess in the lung were soft and purulent, but the cavity was almost empty

This experience remained vividly in my mind and several years later it enabled me to diagnose an acute staphylococcal lung abscess with septicaemia in two difficult cases. Both presented the picture of a lung abscess of 'soap-bubble' appearance, almost empty of fluid in a desperately ill patient. Blood culture was requested in both, and in both a free growth of *Staphylococcus aureus* was obtained One patient, a man with a primary focus in the mastoid,

died; the other, a young nurse with a primary pneumonic consolidation of one lung, made a dramatic recovery with sulphathiazole

Case 2

N M, a probationer nurse aged 21, had been nursing in a whooping cough ward in which were several pneumonia cases On May 6, 1941, she developed what was thought to be a right lower lobar pneumonia, she rapidly became very ill with a high temperature (104°)

had extended to involve the whole of the right lung (Figure 24a) She had begun to cough up purulent sputum on May 10, but at no time was the amount more than half to one ounce It was examined on four occasions and contained a few colonies of haemolytic streptococci, some non-haemolytic streptococci, *Microc catarrhalis*, coliform organisms, and on three of the four occasions, *Staphylococcus albus*

I saw her first on May 15 and my note stated, 'the whole of the right lung is consolidated

of all but air In order to exclude an empyema the base was needled and only a thin layer of clear fluid was found

In view of the continued grave general condition, the empty abscess cavity, and the small

with septicaemia, and should have been recognized as such much earlier

She was at once given sulphathiazole with immediate and dramatic effect, the temperature fell at once and remained normal until her discharge from hospital on July 15 Within one week she was changed from a fretful, dying patient to a cheerful, almost convalescent one

The right lung showed commensurate clearing and a radiograph on July 15 (Figure 24b) revealed scattered fine fibrosis with perhaps several small cavities and an empty 'soap-bubble' cavity in the upper lobe A few moist sounds could be heard over the right lung, but she had no cough or sputum

Considerable interest is clearly attached to the ultimate state of a lung that had been so

She has no clubbing and no dyspnoea A plain radiograph of the chest (Figure 24c) shows slight displacement of the mediastinum to the right and fine 'honeycombing' of the right lung A bronchogram (Figure 24d) shows irregular saccular, chiefly terminal, dilatation affecting all lobes



a *b*

FIG 24*a* CASE 2, May 17, 1941. Total pneumonic consolidation *of the right lung with small* breaking-down areas and an abscess cavity with a fluid level in the lateral part of the right upper lobe

FIG 24*b* CASE 2, July 15, 1941. The pneumonic consolidation has cleared, but fine scarring can be seen and a *large, empty, thin-walled* cavity in the right upper lobe of 'soap-bubble' *appearance*.

After this I began to suspect a staphylococcal cause at once when confronted with a lung-abscess patient in whom the 'soap-bubble' appearance or a large



FIG. 24c. CASE 2, April 10, 1945. There is almost complete clearing of the right lung, which shows a little emphysema and some fine scarring. The mediastinum is slightly displaced to the right.

empty, or nearly empty, cavity was to be seen, and very soon patients were encountered in whom the condition was not always associated with a grave general illness; in other words, it became clear there was a more benign type not associated with severe staphylococcal fever or septicaemia. In fact, the patient with the largest abscess in the series (Figure 26*a* and *b*), although she had been very ill early in her illness, gave no grounds for anxiety at the time



Fig. 24*a* Case 2, May 17, 1941. Total pneumonic consolidation of the *right lung with small breaking-down* areas and an abscess cavity with a fluid level in the lateral part of the right upper lobe

Fig. 24*b* Case 2, July 15, 1941. The pneumonic consolidation has cleared, but fine scarring can be seen and a large, empty, thin-walled cavity in the right upper lobe of 'soap-bubble' appearance

After this I began to suspect a staphylococcal cause at once when confronted with a lung-abscess patient in whom the 'soap-bubble' appearance or a large

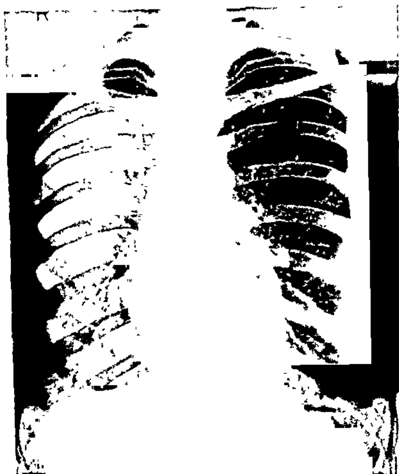


FIG 24c CASE 2, April 10, 1945 There is almost complete clearing of the right lung, which shows a little emphysema and some fine scarring The mediastinum is slightly displaced to the right

empty, or nearly empty, cavity was to be seen, and very soon patients were encountered in whom the condition was not always associated with a grave general illness, in other words, it became clear there was a more benign type not associated with severe staphylococcal fever or septicaemia In fact, the patient with the largest abscess in the series (Figure 26*a* and *b*), although she had been very ill early in her illness, gave no grounds for anxiety at the time



FIG. 24*a*. CASE 2, May 17, 1941 Total pneumonic consolidation of the right lung with small breaking-down areas and an abscess cavity with a fluid level in the lateral part of the right upper lobe

FIG. 24*b*. CASE 2, July 15, 1941. The pneumonic consolidation has cleared, but fine scarring can be seen and a large, empty, thin-walled cavity in the right upper lobe of 'soap-bubble' appearance.

treated expectantly; the fundamental therapeutic approach should be non-surgical. This is not to say that operation is never indicated; indeed, it would be incorrect NOT to operate if there were a definite collection of imperfectly drained or undrained pus. It is, however, essential to consider most carefully before advising operation on an empty, or almost empty, cavity, however big it may be; it is wrong to be influenced towards operation in such cases by the grave toxaemia exhibited by the patient. This is a contra-indication rather than an indication, for an operation will not only do no good, but will add an extra burden to the heavy load the patient is already bearing. That this attitude is not ill-founded is shown by those cases with multiple bilateral abscesses External drainage is then clearly impracticable and conservatism is essential A proportion of these patients will die with expectant treatment, many will get well with or without the aid of chemotherapy and antibiotics, although clearly many more lives will be saved by them Moreover, healing can occur with remarkable restoration of the normal architecture of the lung.

Case 4

Mrs O M, aged 31, had had some 'chest trouble' for ten years, this had consisted of cough with occasional haemoptyses and two attacks of pneumonia On January 28, 1943, [illegible]

blood A radiograph on February 24 (Figure 26*a* and *b*) showed an enormous abscess in the right upper lobe containing a small amount of fluid The appearances suggested, at first sight, an extensive gangrenous pneumonia which should have been associated with abundant offensive sputum in a gravely ill patient Actually, when she was seen on February 26 her temperature was not raised, she had no finger-clubbing, she was not ill, and was coughing only two ounces of purulent sputum A diagnosis of staphylococcal abscess was made and examination of the sputum revealed a heavy growth of *Staphylococcus albus* and *aureus* In spite of the huge size of the abscess, conservatism was advised and this was fully justified by the subsequent course The abscess steadily got smaller and her general health steadily improved, although she was troubled with a constant cough and about one ounce of thick sputum [illegible]
dry [illegible]
26*c*) re[illegible]
ing fi[illegible]
enormous size of the original abscess This certainly suggests the huge size was due to distension rather than destruction

Case 5

E S, a man aged 31, was first investigated in hospital in July, 1942, for attacks of asthma and bronchitis which he had suffered since the age of five On December 25, 1942, he was taken ill with 'pneumonia' and a radiograph on January 8, 1943 (Figure 27*a*), showed massive consolidation of the lower half of the right lung and a huge abscess with consolidation of the upper half of the left lung This was on the fifteenth day of his illness

When seen on January 13 his condition was very grave, his profound toxicity, drowsiness,



FIG 25*a*. CASE 3 Radiograph of the chest four years after bilateral staphylococcal pneumonia with multiple lung abscesses and empyemata A large, thin-walled abscess cavity or cystic space with a small fluid level can still be seen in the right upper lobe.

FIG 25*b*. CASE 3 A bronchogram to show almost complete absence of bronchiectasis, *the bronchi* are displaced so as to surround and envelop the 'cyst.' A left bronchogram showed saccular *bronchiectasis* of the lingula



a *b*

Fig 27*a* Case 5, January 8, 1943 The lower half of the right lung shows massive consolidation due to staphylococcal pneumonitis A huge abscess cavity of typical appearance is seen in the left upper lobe

Fig 27*b* Case 5, February 1, 1943 The pneumonic consolidation of the right lung is now replaced by numerous thin-walled empty abscess cavities giving a massive 'soap-bubble' appearance The giant abscess in the left upper lobe still shows a small fluid level and some surrounding infiltration

The knowledge of the success of expectant treatment in these difficult cases of staphylococcal lung abscess has been a source of great confidence in the



FIG 26*d* CASE 4, January 25, 1944 A right lateral bronchogram to show the condition of the bronchi in the neighbourhood of the original huge abscess Only minimal changes can be seen

management of many subsequent cases However ill the patient has been, and however large or extensive the abscesses, I have recommended continuance of expectant management alone, and in 18 consecutive cases this policy has been followed by the complete recovery of the patient. In a nineteenth case, which occurred during the influenza epidemic of 1943-44, the patient showed no improvement, and another surgeon, quite correctly, sought and found an abscess in the right lower lobe and drained it; the patient died a few days later.

Perhaps the most startling success of conservatism is illustrated in the case of two infants, one aged 9 months and the other aged 19 months.

Case 6

E M , a girl infant aged 9 months, was taken ill on November 11, 1944, and two days later was admitted to St Charles' Hospital with a diagnosis of broncho-pneumonia. Sulphathiazole [illegible] November 18, when the temperature fell to normal, but the abnormal physical [illegible] nsolidation of almost the whole [illegible] n the left upper lobe. Irregular [illegible] f the chest at this time (Decem-



Fig 27a Case 5, January 8, 1943 The lower half of the right lung shows massive consolidation due to staphylococcal pneumonitis A huge abscess cavity of typical appearance is seen in the left upper lobe

Fig 27b Case 5, February 1, 1943 The pneumonic consolidation of the right lung is now replaced by numerous thin-walled empty abscess cavities giving a massive 'soap-bubble' appearance The giant abscess in the left upper lobe still shows a small fluid level and some surrounding infiltration

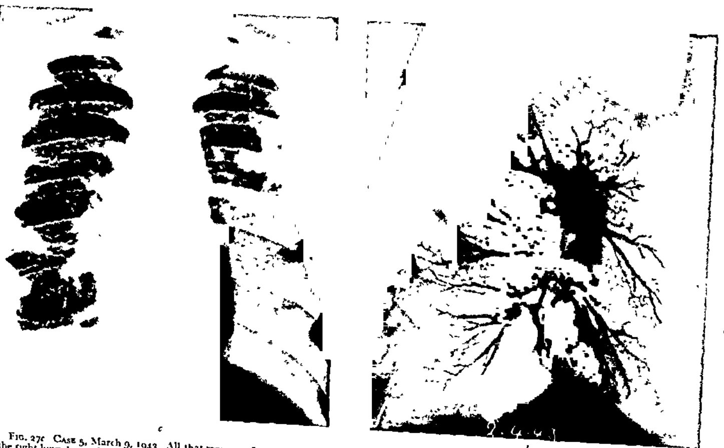


FIG. 27c CASE 5, March 9, 1943 All that *remains of the* abscess in the left upper lobe is a small empty cavity. There has been further clearing of the right lung, but at least two large 'soap-bubble' cavities are still to be seen

FIG 27d CASE 5, April 2, 1943 A right lateral bronchogram to show almost complete resolution of the right lung

and asked me to see the case on December 8, some four weeks after the beginning of the illness

was in an

was made
h the huge
ince in the
lateral view should be noted and also the fact that the cavities are *completely empty of fluid* The radiograph on December 7 (Figure 28*b*) is rather less characteristic, but when compared with the earlier picture it can be appreciated that the same cavities in the lung are there, but under less tension The cavity at the base in the costophrenic angle would do for a

in spite of occasional, although fewer and smaller, bouts of fever Figure 28*c* shows the appearance of the chest on January 12; the left chest is filled by several huge, thin-walled, empty cavities in the lung, the posterior basal cavity especially has increased in size and should be compared with Figure 28*b*.

Steady clinical improvement continued with gain in weight, the child coughed occasionally but produced no sputum

On February 13 the radiographic appearance was as shown in Figure 28*d* The child was still well but was noticed to be dyspnoeic at times The mediastinum is once more displaced grossly to the right by distension cavities so enormous that a pneumothorax is suggested The lateral view, however, especially when compared with that in Figure 28*c*, shows that there are three *intrapulmonary* spaces, the intervening lung being completely airless Aspiration was advised and 200 ml of air were removed. Figure 28*d* shows the lungs on February 22 A few days later still the lungs looked completely normal and the child was discharged from hospital

The recovery in this case was most striking and it is certain that it could not have been hastened by operation. It is more likely that the child would have died

In the next case I was somewhat more hesitant about not operating, but the result again showed that conservatism was justified.

Case 7

A S , a girl infant aged 19 months, was taken ill on December 20, 1944, and was admitted to Guy's Hospital under Dr Cameron She had been coughing and vomiting and was

the sulphai
and respira
ing day 40
growth of S



FIG 28c CASE 6, January 12, 1945 There is now scarcely any consolidation of the left lung, but several *huge*, empty abscess cavities are still present The one at the base has, in particular, increased in size. The lateral view shows the 'soap-bubble' appearance very well



FIG 28*d* CASE 6, February 15, 1945 There is now enormous distension of the cavities in the left lung with gross mediastinal displacement The appearance suggests a pneumothorax, but the intrapulmonary nature of the condition is readily appreciated by comparing the lateral view with that in Figures 28*a* and 28*c*

Confusion with congenital cystic disease in infants

Ignorance of the later appearances of staphylococcal pneumonitis with abscess formation or 'cystic' change in infants is liable to lead to the grave error of performing lobectomy or pneumonectomy. I have seen a number of these cases in consultation in which resection had been planned under the mistaken diagnosis of congenital cystic disease which had recently been infected, or was still infected, and thus palpably demanded extirpation to prevent a fatal or severe recurrence. The conception that the cystic change is primary and the severe infection secondary is understandable, but is still a gross error which is based *on ignorance of the fact that severe staphylococcal* pneumonia is the primary event and the 'cystic' change is secondary and, in almost every case, temporary or transitory. If an adequate time is allowed for observation the 'cystic' disease disappears *completely In these cases it is* common to find that no effort has been made to identify the causal organism, or if the staphylococcus has been found the significance of its presence is not appreciated.

Confusion with diaphragmatic hernia

I have recently seen and operated upon a case of left diaphragmatic hernia in an infant aged 10 months, in which the radiological appearances closely resembled those of staphylococcal pneumonitis with multiple cavities. The early physical signs suggested a pneumothorax, but later loud and numerous bowel noises could be heard in the left chest. The child was vomiting and dyspnoeic and cyanosed, but was not toxic and had no fever.

The Occurrence of Empyema

While emphasis has been laid upon the progression of staphylococcal pneumonia to abscess formation, and, in the case of two infants, the mimicry of empyema by giant lung abscess has been demonstrated, the occurrence of empyema must not be overlooked. Indeed, not a few cases of staphylococcal pneumonia do present themselves as examples of empyema, *and the staphylococcal nature* of the illness may not be appreciated until the pus from the empyema is examined bacteriologically. An empyema occurred in 10 of my 39 cases and was *the cause of their reference* for surgical treatment. When dealing with a staphylococcal empyema due importance must be given to the staphylococcal nature of the infection of the underlying lung. In pneumococcal empyema, by the time the patient co es to the surg e lung condition has usually resolved. This is often ase in a occal infection, and one must be prepared for fev cough, . m to continue even after satisfactory drainage of has be hed.

An extreme example of this was given in Case 3 (R.M.); in 4 of my 10 cases of empyema the lung infection continued to give trouble. In one case recurrent bouts of septicaemia occurred In 2 others death occurred from cerebral abscess. In most of these cases, once the opacity due to the empyema has been removed by drainage, the underlying lung can be seen to be affected by the typical 'soap-bubble' abscess cavities already fully described.

Analysis of 39 Personal Cases

The occurrence of 10 empyemata in the series has just been mentioned. Further brief analysis of this short series is desirable.

Seven of the patients were infants; all the rest were adults. Twenty-six were men and 13 were women. Six of the 39 died; a mortality of 15 per cent; in 2 the cause of death was cerebral abscess, in the remaining 4 a pyaemia or septicaemia was responsible. In 7 patients there was a history of long-standing chest trouble, usually chronic bronchitis, and asthma, the *significance of this has already been mentioned Four cases occurred during* an influenza epidemic

The Late Results of Staphylococcal Lung Abscess

When one sees the severe and extensive damage to the lung caused by a staphylococcal infection it is natural to ask what permanent changes follow. It would appear that in many instances the lungs recover completely. In the case of the two infants the lungs seem to be quite normal, but it is as yet too early to form a sound and final opinion. Fourteen of the remaining patients have no cough or sputum, and the lungs appear normal clinically and by plain radiography, but bronchograms have not been studied.

Bronchograms have been done in 6 patients, and in 4 of these bronchiectatic changes were shown, although in 2 (Cases 4 and 5) the changes were surprisingly slight considering the size of the original lung abscess or abscesses. In several patients a certain degree of emphysema was to be seen in the affected lung or lobe, and in 5 a cystic space or emphysematous-like bulla remained. In Case 3 (R.M) this space has been subject to recurrent attacks of infection with consequent fever, cough, and sputum; the other patients would appear liable to suffer from a similar complication. In the case of N M (Case 2), a considerable degree of bronchiectasis affects the whole lung, but after nine years the symptoms are not severe enough to justify operation, and cough and sputum are decreasing, and it is unlikely that extirpation will be necessary.

To sum up, therefore, of 33 patients who survived, 21 have no indication of permanent lung damage, 12 have symptoms. Of this 12, 6 had had 'chest

irregularities in the other. This appearance can be given by one thing and one thing only, a space formed by separation of a portion of the lung itself; in other words, sequestration has



with those in the lower margin, demonstrating conclusively that the opaque area is a mass of sequestrated lung This was proved at operation

occurred. A similar appearance of a crescent or investing layer of air is given when blood-clot almost fills a cavity in the lung; in the case of blood-clot it is unlikely that there would be irregularities of outline corresponding to similar irregularities on the cavity wall A radiograph a week later showed further separation of the sequestrated lung with a larger crescent of air above it

The patient was transferred to Horton Hospital on January 17; his general condition was fair, but he was raising some nine ounces of purulent sputum. On the following day the cavity was exposed by resection of a segment of the fourth rib in the axilla under local analgesia. The pleura was found to be unusually dense and hard; the abscess cavity was encountered about 1 cm deep to the pleura, and was almost filled by a large, firm lung slough which was still partly adherent antero-medially It was separated by gentle finger dissection but had to be broken into three pieces before it could be extracted. It looked almost exactly like a piece of pneumonic lung in the stage of grey hepatization, from which it differed only in being quite avascular. The wall of the cavity in which it lay was singularly clean and finely granular; only a little inoffensive pus was present This cavity occupied approximately the

lateral part of the anterior segment and the whole of the posterior segment of the upper lobe A little haemorrhage followed removal of the sequestrum and this was easily controlled The wound was packed with zinc peroxide gauze Bacteriological examination of the pus gave a mixed growth of organisms, chiefly pneumococci

He made good progress following this operation, and exactly one month later the cavity had contracted to about 4 cm in diameter He then developed a severe frontal and vertical headache which persisted in spite of all attempts to relieve it Neurological examination revealed no evidence of a cerebral abscess By the beginning of May the sinus had healed and a radiograph of the chest showed almost complete clearing of the lung although he continued to cough about one to two ounces of muco-purulent sputum a day The severe headaches persisted and he was discharged home in June When seen in March, 1949, his headaches were still present, but less severe, he was coughing up several ounces of muco-purulent sputum a day, radiologically the right upper lobe showed contraction and residual fibrosis

To-day, of course, he would have been treated by primary lobectomy and not by external drainage

Although the specific organism was not obtained from the cavity at operation there would appear to be little doubt that the original pneumonia was caused by the *Bacillus friedlanderi* and the massive necrosis of the lung is in keeping with the experience of other authors Thus Taylor (1944) describes a case of a man, aged 43, who developed an acute pneumonia of the right upper lobe He had apparently recovered from this when he again became ill with severe coughing and much foul-smelling sputum A large apical effusion was detected, and at operation, after much thick pus was drained away, a slough of the whole right upper lobe was found lying loose. Examination of the pus revealed a nearly pure growth of *Bacillus friedlanderi* Humphreys (1945) also records two similar cases In one case the patient, a man aged 41, had been ill for two weeks, and a large right posterior basal empyema was found containing foul pus, which on culture yielded a pure growth of *Bacillus friedländeri*, the sputum contained a heavy mixed bacterial flora with a marked preponderance of *Bacillus friedlanderi* Shortly after drainage of the empyema a lung slough, representing a large portion of the lower lobe, was extruded In the second case the patient, a man aged 49, had an empyema in the left upper thorax which followed a very severe pneumonia two months earlier The aspirated pus was odourless and gave a heavy, pure growth of *Bacillus friedlanderi* At operation a large slough of the left upper lobe measuring 10 inches by 8 inches by 3 inches was extruded. Three weeks later the patient developed an abscess of the right upper lobe and the sputum yielded a heavy, nearly pure, growth of the same organism This abscess healed spontaneously.

I have had several cases in which a massive lung slough was found in an empyema cavity, but as the *Bacillus friedländeri* was not identified they cannot be included in this discussion. In the case recorded above the sequestrating



FIG. 31c. CASE 2. Radiographs on October 24, 1944. The left upper lobe now contains a large abscess cavity with a fluid level. No lung sequestration can now be seen

The acute pneumonia caused by *Bacillus friedlanderi* has, from the earliest days of its bacteriological recognition, been notorious for the gravity of the



[illegible] tuberculosis

illness and its high mortality. The clinical course is usually short, and none of the earlier reports describes a chronic form of the disease, although some mention cases of longer duration with abscess formation. The first report of a chronic case simulating pulmonary tuberculosis was by Westermark (1926), who quite clearly recognized it as a special form of the disease. His patient was a man aged 52, whose illness lasted six months. Before this the longest cases in the literature were of eight weeks' duration The radiographic appearances immediately before death were those commonly interpreted as being due to pulmonary tuberculosis and consisted of cavities in both upper lobes, the right lung being worse than the left. At autopsy there was no



Fig. 31c. Case 2 Radiographs on October 24, 1944 The left upper lobe now contains a large abscess cavity with a fluid level No lung sequestration can now be seen

The relative incidence of foetid and non-foetid and of acute and chronic cases in Group A has already been given in tables on page 41 (Chapter IV) and will not be repeated now.

TABLE IV

GROUP A BASIC AETIOLOGY OF 392 CASES OF LUNG ABSCESS (1942–50)

Total	392
Bronchial carcinoma	74 (18 9%)
Other causes identified	229
Total causes identified	303 (77 3%)
Cause obscure, 'Primary'	89 (22 7%)

TABLE V

GROUP A AETIOLOGY OF 318 NON-MALIGNANT CASES

Non-malignant		318
Post-operative		68 (21 4%)
Abdominal	35	
Non-abdominal	33	
Tooth extraction	22	
Tonsillectomy	5	
Dental sepsis		57 (18%)
Various causes		69 (21 7%)
Specific infections		34 (10 7%)
Staphylococcus	25	
Streptococcus	1	
Friedlander	4	
Actinomyces	4	
Upper respiratory infection		17
Lower respiratory infection		21
Obscure, 'Primary,' 'Cryptic'		90 (28 2%)
Cause identified		228 (72 8%)

It will be noted that in 64 per cent no cause could be found even aft careful inquiry. However, in 84 per cent of this group the finding of b teeth, heavily encrusted with tartar associated with infected gums, strong suggested an aetiology. As a control 100 patients were investigated who we referred from the wards for dental treatment; comparable dental sepsis w present in only 12 per cent. As a further control 50 patients attending t chest clinic follow-up were examined and bad teeth were noted in only 14 p cent Stern completes his argument by emphasizing that the commo organisms found in acute foetid abscess are those organisms, chiefly spir chaetes and fusiform bacilli, which are normally found in the mouth and ca be easily recovered from the tartar masses and pus pockets. This materi introduced into the lungs of experimental animals has been shown to cau lung abscess. In another communication (1935), Stern comments on t incidence of putrid abscess following dental operations and found that 12 such cases 8 followed local analgesia, 3 followed nitrous oxide, and in on no anaesthetic was used. The last case is of extreme interest and followe ordinary scaling for removal of tartar; presumably a small infected fragmen was actually inhaled and formed the causal bronchial embolus

There can be no doubt that in this recognition of the importance of denta sepsis we have one of the common and important causes of many lung ab scesses, especially many of those heretofore labelled as 'idiopathic' Whe dental sepsis of this type is associated with an operation the stage is set fo the probable experimental production of a lung abscess in man, and I hav often observed, when asked to see a case of post-operative lung abscess, tha gross dental sepsis is present and has been left untreated before the operation It is certain that in many of the cases labelled as 'post-operative' in the usua analysis of the causes of lung abscess, a high proportion were really due to neglected dental sepsis acting as the main factor.

Personal Experiences

The part played in the production of lung abscess by inhalation of infected material to form a bronchial embolus has been discussed in Chapter II and elsewhere (Brock, Hodgkiss, and Jones, 1942), and it is not proposed to elaborate the basic argument now, but chiefly to try and emphasize the fundamental truth of the conception by the analysis of a group of cases seen, and by the presentation of a number of selected cases.

The chief material consists of 392 consecutive cases of lung abscess personally seen in the nine years 1942–50 (Group A) with the addition of an earlier series of 85 operation cases (Group B), although it is felt that this group is not so comprehensive as the larger group of unselected ones.

The relative incidence of foetid and non-foetid and of acute and chronic cases in Group A has already been given in tables on page 41 (Chapter IV) and will not be repeated now

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Lower respiratory infection		21
Obscure, 'Primary,' 'Cryptic'		90 (28 2%)
Cause identified		228 (72 8%)

cent of Stern's series and 7 per cent of my own cases. This is a very disquieting figure and it is high time that the frequency of this complication is more widely recognized. Three factors would appear to be responsible, all of which may act together in varying grades of importance. These are:

(*a*) Multiple extractions under deep anaesthesia;
(*b*) Extraction of septic teeth with tartar masses;
(*c*) The upright position in the dental chair.

It is possible that a fourth might be added; namely,

(*d*) Badly given nitrous oxide anaesthesia with cyanosis and obstructed respiration.

(*a*) *Multiple extractions under deep anaesthesia*

Of the 29 cases of lung abscess following tooth extraction in this series, 9 followed complete clearance of the mouth under general anaesthesia; in 6 cases all the teeth were extracted in one operation; in 3 in two operations. In 2 of these cases the clearance was made under chloroform anaesthesia in a doctor's surgery and the patient was sent home afterwards In 3 cases the clearance was done under nitrous oxide anaesthesia, in 2 under evipan. In all the cases dental sepsis was present before the operation; most had pyorrhoea

When one considers the large, raw, bleeding area resulting from such a procedure, with its discharge of infected material, clots, shreds of infected mucosa, and often with tartar fragments, it is clear that there is grave danger of considerable bombardment of the lungs with potentially dangerous bronchial emboli. The concomitant deep general anaesthesia, or the cyanosis and obstructed respiration of a prolonged and possibly indifferently administered nitrous oxide anaesthesia, provide almost ideal experimental conditions in man for the production of a lung abscess.

The practice of complete clearance of infected teeth in this way seems both undesirable and, indeed, reprehensible.

In 8 cases six to eight or 'several' teeth were extracted in one sitting; in the remaining 12, one, two, or three were extracted.

(*b*) *Tartar masses*

If much gum infection with pus pockets and tartar masses is present it is certainly undesirable to proceed to extraction at once. Such teeth first require scaling and cleaning [illegible] so that when
the extraction is done [illegible]
of actual particulate m[illegible]
as much as possible.

Although it is commonly assumed and taught that lung abscess is likely to

follow inhalation of a tooth after extraction, this is, in fact, a rare cause and a much less likely cause than that just mentioned. Actually, in most examples of inhaled tooth or tooth fragments no true lung abscess is caused but a diffuse septic broncho-pneumonia.

(c) The upright position in the dental chair

This position seems hallowed by custom, but it is desirable that dental surgeons should consider seriously its dangers Its popularity presumably depends on the comfort and efficiency in performing the actual extraction in the surgery or out-patient clinic. It is clear that the position greatly favours inhalation of blood and of infected material, and it is certain that if patients were examined with a bronchoscope afterwards, such material would be found in the lungs in a high percentage of cases, as has already been demonstrated after tonsillectomy In many the blood is cleared by ciliary action and coughing, but in others it constitutes a real danger Packing the pharynx may give some protection, but unless the patient is to be suffocated by the pack it is clear that the airway cannot be completely protected; in any event, the removal of the pack at the end of the operation leaves the larynx vulnerable and at a phase of anaesthesia when stertor and cyanosis are often present. Multiple extractions under general anaesthesia should certainly be carried out with the patient supine.

Even during the recovery phase, when the patient is lying down, there is a grave danger of inhalation of dangerous material, especially if free bleeding or oozing continues, this is shown by the incidence of abscess in the upper lobes The question of the safest posture during recovery from anaesthesia, especially after operations upon the nose, mouth, and pharynx, will be considered later

(d) Badly administered nitrous oxide anaesthesia

The administration of an anaesthetic agent exposes the patient to the risk of inhalation of material into the lungs from the upper air passages. Smooth, even, and skilfully administered anaesthesia reduces this risk to a negligible amount, but in the current use of nitrous oxide we have a method which is peculiarly dangerous in this connection, more particularly since it is more liable to be given unskilfully Cyanosis, jactitation, laryngeal spasm, and arrested breathing are common, and the respiration may be even more obstructed by depression of the mandible during the actual extraction. When recovery occurs, a violent act of inspiration is made, often with crowing, at the very time that the mouth and pharynx contain blood and tartar fragments, etc. Experience of the extraction clinic also teaches that it is the middle-aged, plethoric type of man with a mouth full of foul teeth who so often 'takes gas badly,' and it is this type who is often found to develop a lung abscess after

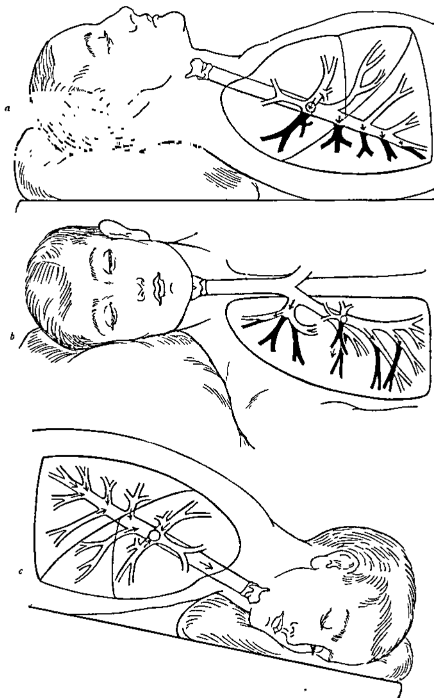


FIG 33 Diagrams to show the influence of posture during recovery from anaesthesia on the distribution of bronchial secretion or inhaled material. '*a*' Supine, the dorsal segments of the lungs are vulnerable '*b*' Lateral, the axillary areas are vulnerable '*c*' Prone, with head-down inclination of the body, the most favourable position to avoid inhalation of secretion and inhaled material

embolism (Figure 33c) Fewer bronchi are vulnerable in this position, and their direction is such that if, in addition to his lying prone, the patient's feet

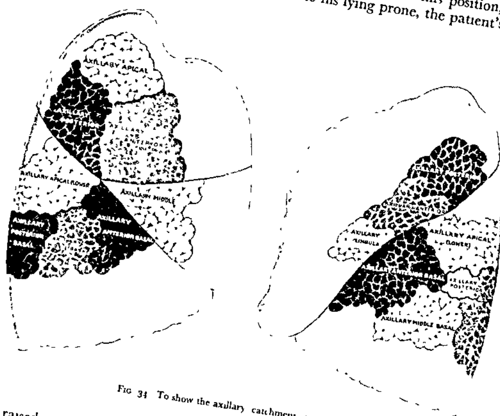


FIG 34 To show the axillary catchment areas

are raised so that his body is on a slightly inclined plane, the risk of embolism is still further lessened The position should be used as a routine during recovery from anaesthesia after any operation upon the upper air passages It could also be used with advantage after recovery from an abdominal operation, except that the pain of the wound may make it intolerable

Lung Abscess due to Causes other than Operation

In the complete series of 477 cases (Groups A and B), 83 (17 5 per cent) were due to a malignant lung growth, a separate chapter is devoted to a fuller consideration of this problem. It is sufficient to mention now that in

rence during an influenza epidemic supports such an aetiology. It is obvious, however, that in such cases it is difficult to differentiate from a primary or specific pneumonitis proceeding to abscess formation. The more cases of specific pneumonitis that are recognized and correctly classified, the smaller will this group be In many of the published analyses of aetiology, upper and lower respiratory infections as a cause are more numerous than in my series, but often this is admittedly because 'broncho-pneumonia,' etc., is loosely included in this group. It is uncommon to find any attempt at recognition and separate classification of specific lung infections.

Specific infections of the lung; 'primary,' 'cryptic,' or obscure abscesses

A specific infection was recognized as the primary cause in 36, 9·2 per cent; 27 of these were staphylococcal, 4 were due to *Bacillus friedlanderi*, and 4 were actinomycotic. Only one is specifically classified as streptococcal in spite of the fact that in several the bacteriological examination supported a primary streptococcal infection; it was felt that the evidence was not completely conclusive, and these others have been included in the group of 'obscure' or 'cryptic' infections.

This group consists of 115 cases (29 per cent) and it is a miscellaneous group made up of all those cases in which no primary or antecedent cause could be recognized No doubt more careful or more skilful inquiry would have enabled a number of cases in this group to be classified under another heading. It is doubtful if many more could have been separated off in this way, and almost all can fairly certainly be taken to be cases of primary lung abscess in which it has not been possible to identify or in which one has failed to recognize the specific nature of the infection. As was stated in Chapter IV, this group must of necessity be a convenient means of concealing the present limitation of our knowledge and that, as this knowledge increases, certain members or types may be recognized and transferred to other groups.

Lung Abscess in Infants and Children

Children of 14 years or under numbered only 15 in this series, and it is noteworthy that it was almost always possible to assign a primary cause to the abscess. This is as one would expect; it is most unlikely that a child should develop a lung abscess except for a very definite reason.

In 8 the cause was a primary staphylococcal pneumonitis; 7 of these were infants, 18 months of age or under, one was 11 years old.

Tonsillectomy was the cause in 3, one followed an operation for acute appendicitis; another followed pneumonectomy for a heavily infected bronchiectasis. In one the cause seemed to be infection of a congenital cyst and the remaining one proved to be tuberculous.

Graham (1926) found that 40 out of 218 cases of lung abscess (18·3 per cent) were in children under 12 years. Smith (1934) found that out of 2,250 cases of lung abscess in the American literature, only 59 were in infants and children. After excluding those due to
45 and states that 24 followed pneumoni
due to a foreign body, one to exposure,
(1945) discusses 64 cases of lung abscess in children 13 years of age or younger; these occurred in a series of 417 cases of lung abscess seen by him between 1931–41 (10·5 per cent), 19 of this 64 (29 per cent) were aged one year or younger. The causes indicated by D'Ingianni were 'pneumonia' in 32 per cent and tonsillectomy in 19 per cent.

It appears certain that acute staphylococcal pneumonitis is by far the commonest cause of a primary lung abscess in children and especially in infants. This fact should always be remembered when confronted with a case, and appropriate chemotherapy should be given at once Guthrie and Montgomery (1947) have recently emphasized the gravity and frequency of staphylococcal pneumonia in childhood. Smith (1936) states that he believes staphylococcal pneumonia is the aetiological agent in at least 75 per cent of primary bacterial abscesses, and 50 per cent of all abscesses in children.

Most of the other abscesses in children are post-operative and tonsillectomy leads the way in these.

Lung Abscess in Young Adults

It is useful to consider the aetiology in the case of young adults, this series included 40 patients between 15 and 25 years of age; 26 were men and 14 were women

In 11 cases the absces
an
loc
caries may be rife at this age, gross gum infection with tartar masses and pus pockets of the type commonly associated with lung abscess has not usually had time to develop. In one case the abscess followed electro-convulsive therapy, Kwalwasser, Monroe, and Neander (1950) have recently described 25 cases occurring in 2,562 patients submitted to this treatment, an incidence of 1 per cent Nasal feeding was a probable factor in 7, but my own experience suggests that untreated dental sepsis is a fruitful cause.

The commonest single cause next to operations was *bronchiectasis* (5 cases) In the absence of any other likely predisposing factor in a young adult, bronchiectasis should always be suspected and appropriate investigations made The abscess may occur within the diseased lobe, but is more often a 'spill-over' lesion, i e. one due to 'internal bronchial embolism'; it may

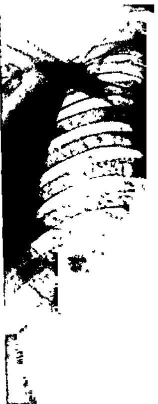








Fig 36 Case 3 Chronic abscess of the middle lobe A large cavity is present in the anterior segment

spine; he had been a coal-heaver since the age of 15 years. It will be appreciated that when he was carrying sacks of coal, bent forwards so that the rigid platform formed by the flat upper thorax was almost horizontal, the middle lobe area was the most dependent and therefore the most vulnerable (Figure 37) The necessary posture is, therefore, satisfied

On his return to work after an absence of over four months it was inevitable that he, an emphysematous man of 61, should find coal-heaving a heavy strain, and he volunteered the information that it made him very short of breath It is not difficult to imagine him valiantly struggling with his 1 cwt and 2 cwt sacks of coal on his back, puffing and grunting and [illegible]

here was the mechanism of inhalation at the very moment in which his posture was favourable for middle lobe embolism, and par[illegible]

If this hypothesis were correct [illegible]

certainly an inflammatory abscess [illegible]

drainage and intramuscular penicillin, but by November 15 he was still coughing up six ounces of purulent sputum, and radiographs still showed an abscess cavity Operation was advised, but he refused to accept it and again refused on December 1, and later discharged himself

In May, 1945, he was readmitted to hospital gravely ill with a streptococcal pericarditis and was given penicillin A massive haemorrhage occurred into the pericardium from the abscess and he died on May 27 Autopsy showed no carcinoma but a chronic abscess of the medial segment of the middle lobe perforated into the pericardium.

It was stated above that carcinoma of the middle lobe is uncommon and that most lesions affecting it are inflammatory. Examples have been given of the influence of posture on the localization of an abscess to this site In the absence of this postural selection there is another mechanism for the production of suppuration and abscess formation in the middle lobe

It has been pointed out elsewhere (Brock, 1943, 1946, and 1950) that the middle lobe bronchus is peculiarly vulnerable to compression from tuberculous glands arising as part of a primary complex The middle lobe bronchus is relatively long, its walls are soft and poorly supported, and it is surrounded by a number of glands draining both the middle and lower lobes. Not only is it often compressed by these, but a caseous gland may adhere to the wall, ulcerate through, and discharge part or all of its contents When healing occurs, a stricture follows and the middle lobe often remains shrunken, fibrosed, and bronchiectatic, although it may cause no symptoms for many years, infection sooner or later supervenes. The infection may be low grade, but if it is at all severe, resolution is rendered more difficult because of the stricture; moreover, in a proportion of these cases broncholiths are present

Case 4

F Y., a gas [illegible]
taken ill with [illegible]
was made at [illegible]

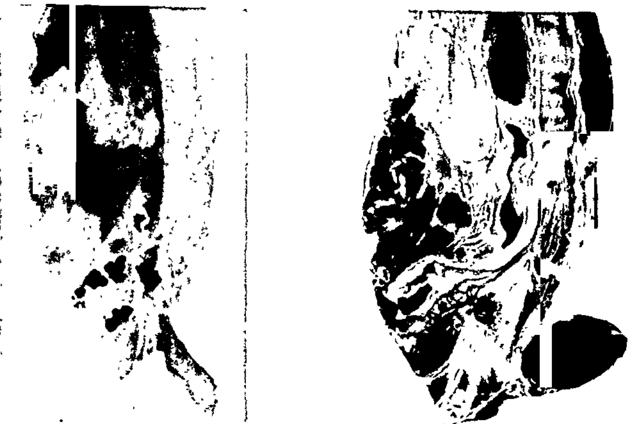


Fig. 38 Case 4 Suppuration and chronic abscess of the middle lobe due to broncho-stenosis and *broncholiths* *In 'a' a radiograph of the specimen* shows numerous calcified areas, some of which are in *lymph glands*; others, as shown in '*b*,' are lying loose in the middle lobe *bronchus* as 'broncholiths'

but later
with blooc
to hospita
noma, but radiographs showed consolidation of the apical and posterior segments of the right upper lobe with extension to the lateral division of the middle lobe and some excavation; a lesion of such anatomical extent was not likely to be due to a carcinoma Bronchoscopy revealed nothing but pus in which the predominant organism was *Streptococcus viridans*, the teeth were in good condition The sputum steadily increased to five ounces

There seemed no adequate explanation for a diffuse pneumonitis with abscess formation such as this seemed to be, and repeated inquiry revealed nothing. He was specifically asked if he had been intoxicated, had been exposed to hard weather or undue fatigue, or if he had suffered immersion It was only after several searching inquiries (searching because a diagnosis of carcinoma still remained a probability in the absence of a demonstrable primary cause) that he half-heartedly said the only thing he could think of was exposure to petrol fumes This did not seem a likely factor, but when asked for more details he revealed that he and another man had gone down to the engine-room of a mined and beached ship to stop an escape of petrol The other man was overcome with fumes, he himself nearly collapsed, he was further pressed for details, and described how he had to bend down close to a valve, from which liquid petrol was escaping in a fine jet, and to close the valve, he estimated his face was about twelve inches from the petrol jet It is not unreasonable to suppose that working in this confined space so close to a liquid jet he inhaled actual petrol droplets and not just gaseous fumes His illness developed a week or two later

The course of the lung lesion was interesting, as the consolidation in the apical segment of the upper lobe cleared, the consolidation lower in the lung increased and extended Eventually, by August, 1945, all the infiltration had gradually cleared, and residual slight fibrosis with considerable bullous emphysema remained

Morriston Davies described a similar slow creepage throughout the lung in two cases of lung abscess due to inhalation of sea water and fuel oil, incidentally, in these cases the first abscesses developed in the middle lobe and lingula. Lawrence (1945), in discussing acute poisoning due to petrol vapour, states that in fatal cases the macroscopic changes are found for the most part in the lungs, which are hyperaemic and oedematous and show petechial haemorrhages and extravasations of blood; the bronchi are inflamed

did not share this view

Fatigue and exposure

In obscure cases of lung abscess it is always desirable to inquire about unduly severe exposure to weather or to excessive fatigue, and also to any habits of life that might lead to gross impairment of general health These occur sufficiently commonly as accompaniments of lung abscess to suggest a causal relation. It is again not unreasonable to assume that great fatigue or exposure may so lower the general resistance as to favour the development

operation, gross dental sepsis is next considered and identified or excluded. The older the patient the more likely is this to be a cause. On the other hand, it must be remembered that the septic teeth may be only coincidental and that the patient may also have a bronchial carcinoma. Certainly in any patient over 50 who presents with a lung abscess with no obvious primary cause, a growth must be thought of and identified or excluded; the incidence of growth in cases of lung abscess is 17 per cent in this series.

Next a specific pneumonitis with abscess formation must be considered; especially if the initial illness is severe and particularly if a septicaemia is suggested or it occurs during a season of severe respiratory infection or in a frank influenza epidemic. Staphylococcal pneumonitis is by far the commonest cause, Friedlander and streptococcal infections next; a blood culture is often the best and most certain way of identifying the causal organism; bacteriological examination of the sputum is liable to be uncertain. In a few cases the lung suppuration, more particularly if it is bilateral and patchy, will be due to pyaemic embolism from a systemic focus such as osteomyelitis, carbuncle, septic cellulitis; more rarely still, an endocarditis affecting the right heart will be the cause. Here again the continued gravity of the patient's general condition should serve as a guide and blood culture should assist.

Conditions giving rise to deep unconsciousness, apart from general anaesthesia for an operation, must be reviewed and specific questions asked; they include alcoholic intoxication, coma from overdose by hypnotic or sedative drugs, carbon monoxide, or other similar poisoning, eclamptic or uraemic coma, epilepsy, or unconsciousness following a head injury. In any of these, especially post-epileptic coma, dental sepsis may be a contributory or determining factor, and in the case of injury, inhaled blood may be the causal embolus. Of 4 cases following head injury in this series, 2 had a fractured skull, the other 2 had also a fractured mandible; fracture of the mandible, in addition to causing bleeding, favours accumulation and retention of secretions and debris within the mouth and pharynx, and the risk of inhalation is therefore not inconsiderable.

Immersion comes next and, again, must be specifically asked about In some localities with a riverside dockworking or seafaring population this cause increases in importance and is often aggravated by dental sepsis or by intoxication; for this last reason a specific question must always be asked. A clue may be afforded by the anatomical localization of the lesion of the lung, indicating a particular or characteristic posture at the time of probable inhalation. The lower anterior parts of either lung (i.e. the middle lobe, lingula, and anterior basal segments) are favoured in immersion. The selective localization of post-tuberculous broncho-stenosis to the middle lobe must also be remembered.

Tuberculosis always demands exclusion with the utmost vigilance; examinations for tubercle bacilli should be repeated many times even in the

apparently more unlikely cases or when a good primary cause already presents itself. For instance, in the case of a middle-aged man who had an abscess of the right upper lobe, the illness followed soon after he had been given a dose of morphia while suffering from a quinsy; after sleeping heavily, he found both the pain and the quinsy gone when he awoke. The sputum was repeatedly negative for tubercle bacilli, but secretion obtained at bronchoscopy was reported as positive; it was not until several months later that the sputum itself became positive. In another case a girl of 18 developed a severe streptococcal septicaemia following an acute streptococcal tonsillitis; blood culture was positive. A few days later she developed what appeared to be a classical abscess of her right lower lobe. Sputum obtained at bronchoscopy revealed tubercle bacilli and the sputum was then also found to be positive.

Recently Pryce (1946) and Pryce, Sellors, and Blair (1947) have pointed out the occurrence and significance of included supernumerary bronchopulmonary segments. These occur in the lower lobes and when infected may present as examples of lung abscess; once suppuration occurs, spontaneous resolution never follows. Five of my own 7 cases of this condition have presented as examples of chronic lung abscess; one of these patients had already had two drainage operations Lobectomy is necessary to achieve a cure.

Even after all these possible primary causes of lung abscess have been carefully considered a number of cases will still remain, probably about 30 per cent, in which it has not been possible to identify a primary cause. It will then be justifiable to consider this remaining group of obscure cases as probably, or possibly, constituting examples of primary lung abscess in which the nature of the specific cause or infection has not been recognized. Even then it is probable that this group represents in great part, not the true incidence of primary, obscure lung abscess, but is rather a measure of our present state of ignorance of the aetiology of lung abscess

When the abscess forms within the primary growth it can conveniently be described as 'primary'; when it is not part of the primary growth it should be described as secondary.

Malignant lung abscess (83 *cases*)

I. *Primary:* Due to breaking-down growth itself; 52 cases.

II. *Secondary:* a. In obstructed infected lung distal to growth; 24 cases.
b 'Spill-over' abscess in same lobe, another lobe, or even in the other lung; 7 cases.

It is sometimes difficult to make this distinction with accuracy between a primary and secondary abscess due to growth, for an infected breaking-down growth may also give rise to an obstructed and infected lobe which contains an abscess resulting from the infection but in direct continuity with the primary growth (Diagram *d*, Figure 39).

It is not uncommon to find that when a lung containing a growth, removed either at operation or autopsy, is cut open, an abscess cavity is revealed that had been hidden in a homogeneous opacity during life and had not revealed its presence clinically by the production of large amounts of sputum. Such cases are not included in this study which deals only with cases which presented in life as examples of lung abscess, clinically or radiologically. In most cases the diagnosis was both clinical and radiological; in a certain number the diagnosis of lung abscess was primarily radiological.

Primary lung abscess (52 *cases*)

In primary malignant lung abscess the growth is commonly of the circumscribed or 'parenchymatous' type and forms a rounded, oval, or slightly

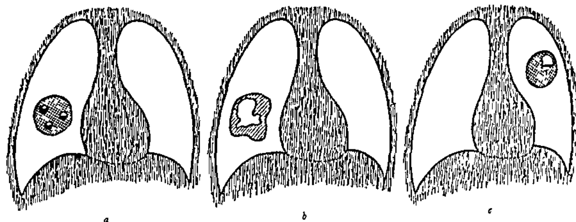


Fig 40 Diagram to illustrate different ways of formation of a primary malignant lung abscess
Fig 40*a* Large opacity with one or more central cavities
Fig 40*b* Large cavity with relatively thin wall, although wall often shows irregularity and nodularity
Fig 40*c* Eccentric cavitation

lobulated mass situated within the substance of the lobe and is usually well defined It may sometimes be so large as to fill the greater part of a lobe, in which case its outline is blended with that of the parietes, occasionally, in 5 cases in this series, the overlying ribs may be eroded. Almost invariably a

y abscess is of the squamous-
tion, and hence the size and
onsiderably It may be small
three small cavities are seen
Figure 40). Conversely, the

greater part of the growth is necrotic, and a large cavity lined with growth is formed with a wall that may be thin or moderately thick; most significantly the wall is irregular in thickness or may present nodularities (Diagram *b*, Figure 40, and Figures 41 and 42) As a blend of these two extremes the abscess may be, proportionately to the opacity, of moderate size and may be placed eccentrically in the opaque area (Figure 43). If looked for and noted radiologically, this last fact may be of considerable diagnostic significance Erosion of an overlying rib or ribs is virtually diagnostic of growth (Figure 45).

Secondary abscess (31 *cases*)

When a lobe or lung is infected behind an obstructing primary bronchial growth the most common process is a diffuse septic pneumonitis with gross septic bronchiectasis. Secondary lung abscess, type *a* (24 cases), occurs more commonly in the period in which the obstruction is incomplete or intermittent. The abscess may be small, or several cavities may form, or a large solitary abscess may be present (Figure 44) The abscess may be so large as to be mistaken for an empyema, and it may be drained externally as such. It is, of course, not uncommon for a true empyema to be caused by the suppurating pneumonia, and this again may cause postponement of recognition of the underlying growth

In general, as the bronchial obstruction becomes complete, the solid part of the infected lobe or lung dominates the clinical and radiological picture, and the actual abscess element may become less important. This type of abscess may be caused by any histological type of growth that causes bronchial obstruction; it may also, of course, be formed in association with a non-malignant primary bronchial growth such as an adenoma, chondroma, or fibroma. In some cases the abscess cavity is formed, not as a result of necrosis within septic pneumonic lung tissue, but by the gross dilatation of a single bronchus (Figure 46)

Secondary lung abscess, type *b* (7 cases), due to 'spill-over' infection from a primary growth elsewhere in the lung is usually small and localized, but may be a diffuse, spreading process ultimately affecting a whole lobe. It may occur in the same lobe as the primary growth but affecting an adjacent



a b

Fig. 41. Radiographs of a typical malignant lung abscess due to a breaking-down growth (primary type of malignant abscess).
Fig. 41a The medial wall of the abscess is thin and cystlike, but the lateral wall *shows an obvious*, irregular projection due to growth
Fig. 41b. Shows the same case a few weeks later and thick, irregular growth now lines the whole cavity. The malignant nature of this abscess had not been recognized by the earlier attendants.

segment. When it occurs in the lung opposite to the primary growth it usually affects one of the classical sites for an inhalation lesion. The clinical picture,

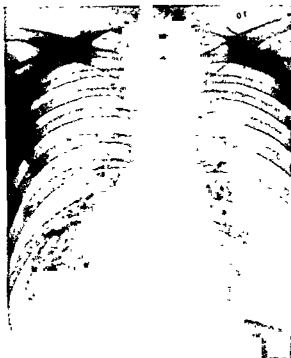


FIG 42 Radiographs of a malignant abscess of the right lower lobe in a man aged 55, most of the cavity is thin and cystlike, but a nodular mass projects in from the medial wall Biopsy of this mass at external drainage revealed a squamous-celled carcinoma

and thus the diagnosis, may be very confused in this type of case, and it is important to remember the possible course of events when confronted with multifocal or bilateral lung suppuration in a middle-aged or elderly patient; otherwise a mistaken diagnosis may be made of 'idiopathic' or 'primary' suppurative pneumonitis with abscess formation The primary growth may be of any type that causes infection and is thus more commonly one affecting a lobar or segmental bronchus.

Clinical and Radiological Features

A lung abscess due to carcinoma may present clinically in a number of different ways, but, broadly speaking, there are two main forms of presentation. The illness may begin and continue as a febrile one with purulent



a



b

Fig 43 Malignant abscess of the anterior segment of the right upper lobe in a man aged 60 Note the eccentric cavitation in the radiograph in '*a*', the specimen is shown in '*b*,' and the nodular growth lining the abscess cavity can be seen



Fig 41 Abscess of the lateral region of the right upper lobe secondary to a primary carcinoma of the right upper lobe bronchus Note the hilar mass, the wide mediastinum, and the high diaphragm

Figure 42 the greater part of the cavity wall is thin and cystlike, but a nodular mass projects in from the medial wall of the cavity.

The abscess cavity may form a relatively small part of an opacity, rounded or oval, the greater part of which consists of solid neoplastic tissue. The suggestive feature of eccentric cavitation has already been mentioned, as well as the diagnostic importance of rib erosion (Figure 45). In this case pain is severe and persistent; in other cases pain may be an early symptom, but it is often absent or occurs as a temporary or intermittent pleuritic phase.

Fever may be absent or intermittent, although in some cases bouts of high fever, often diagnosed as pneumonia, may occur. It is in the febrile cases, associated with copious purulent sputum, that a diagnosis of simple lung abscess is usually made, and, indeed, it is often extremely difficult, and at times impossible during life, to obtain confirmation of the diagnosis of carcinoma although the age, localization, and general features of the abscess may arouse strong suspicions. Glandular or hepatic metastases are uncommon; osseous deposits may occur, but cerebral secondaries are by no means uncommon and may be the first definite indication of the malignant nature of the lung lesion. Even then the differentiation from a pyogenic brain abscess may be difficult, and in some cases the secondary deposits may be infected and consist of an outer zone of living growth enclosing a suppurating, necrotic centre.

The sputum varies greatly in character, being muco-purulent, blood-stained, or purulent; it may be inoffensive or it may be highly offensive, thus suggesting a primary putrid or foetid lung abscess. An example of this is given in Case 4 described later when treatment is being discussed.

The amount and character of the sputum and the degree of cough associated with it may constitute by far the most important clinical feature. In the unhappier cases the patient has a frequent, almost continuous, cough, giving neither him nor his companions or attendants any respite by day or night; abundant purulent, blood-stained, and often offensive sputum is raised, causing great distress and demanding a relief which sometimes cannot be provided.

As in all forms of lung suppuration pleural involvement may occur with fluid formation, progressing to empyema in some cases.

Secondary inhalation abscess or focal pneumonitis may be seen as in Case 4, Figure 49*a*.

Secondary malignant lung abscess

In this group, although the onset or earlier stages may be insidious, the chief manifestations are essentially infective in nature since the abscess is due to suppuration behind an obstructing growth or to 'spill-over' from an infected growth. Just as in obstructive bronchial carcinoma without frank abscess

formation, the onset may be relatively mild, resembling a 'chill' or an attack of 'influenza' that does not resolve completely; or it may be severe and abrupt, resembling and often diagnosed as an attack of 'pneumonia.' The persistent and increasing productive cough and radiological demonstration of an abscess cavity then almost inevitably leads to a diagnosis of simple lung abscess In a young patient the clinical mimicry of a simple acute lung abscess may be very close and the diagnosis may be made only fortuitously at routine bronchoscopy, or if biopsy of the abscess wall is made, although continued relapse or chronicity in the absence of an obvious cause should arouse suspicion. In the youngest patient in this series, for instance, a woman aged 39, the condition presented as an apparently simple abscess of the subapical region of the right lower lobe and was drained externally; biopsy of the outer wall of the cavity showed no growth The cavity did not heal satisfactorily; after temporary improvement the general health declined, and it was not until death occurred several months later from cerebral metastases that a primary oat-celled growth was found in the lung.

In secondary malignant lung abscess the sputum may also be offensive and may be scanty or abundant in quantity. Blood-staining occurring frequently or persistently is of great diagnostic value and may be the most certain clinical indication of growth.

Whereas in primary malignant lung abscess a number of characteristic radiological features may be present, the radiological differentiation in secondary lung abscess may be less certain Persistent lobar consolidation, especially if associated with shrinkage indicating atelectasis, is suggestive, but often occurs with a non-malignant suppurative process; of greater value is the recognition of an associated hilar mass Glandular and visceral metastases are much more common than in the primary malignant forms and should always be carefully sought; a barium swallow to indicate oesophageal obstruction or distortion should never be omitted. Bronchoscopy is, of course, of the greatest value in diagnosis.

In both primary and secondary forms of abscess, although the presence of a growth may be suspected and evidence of its presence sought for diligently, it may be impossible to obtain an absolute diagnosis before necropsy. These patients are often elderly and frail, and such poor subjects for operation that open operation, which alone would provide the diagnosis, is often not feasible.

External drainage will often enable a diagnosis to be made from microscopy of the outer wall of the cavity; it is also important to inspect the inner wall and, if possible, to obtain tissue for biopsy from the deeper parts. Obvious growth may be seen if the interior is inspected with a good light.

The clinical differentiation between a simple chronic abscess and one due to growth may be at times impossible even when the lung is exposed at open thoracotomy, and in such cases a final diagnosis can be made only when the

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excised lung is examined. It is sometimes a nice point at operation whether to perform a pneumonectomy in such a case or to conserve a lobe when real doubt exists.

Case 1

H M., a man aged 39, began to feel ill in June, 1947, and a radiograph on June 16 showed a small peripheral, sub-segmental opacity in the left upper lobe; ten days later the opacity was larger and an enlarged gland was present at the left root. He complained of occasional *stabbing pain in the chest;* night sweats occurred, but no fever; cough was present, and he produced a little foul-tasting but never foul-smelling sputum, which was occasionally blood-stained Bronchoscopy was negative, no malignant cells were found in the sputum A bronchogram showed a block of two small branches of the *posterior bronchus of the left upper* lobe, and this was thought to support the diagnosis of an inflammatory lesion. The shadow and symptoms persisted and by September 12 it was felt that a final decision must be made. Independent radiological and clinical opinions favoured growth and thoracotomy was performed on October 9 A firm mass was present in the periphery of the posterior segment [illegible]

[illegible]

perform pneumonectomy and not to risk a lobectomy.

Examination of the excised lung revealed a small, chronic lung abscess with no growth

In this case lobectomy would have sufficed and the lower lobe might have been conserved with advantage, but the lesion might equally well have been found to be malignant and the lesser operation would have been regretted.

Conversely, operation for what was thought to be a non-malignant condition may reveal an obvious growth.

Case 2

C.B., a man aged 53, had suffered from a chronic cough for many years, and in May, 1947, [illegible] cough and sputum [illegible] except the lingula, [illegible] ment. The sputum [illegible] is coming from [illegible] tis with tartar masses, and it was considered the dental sepsis was severe enough to account for the lung suppuration He was treated with 1,000,000 units of penicillin a day and the teeth were scaled and cleaned, there was some improvement following this

Bronchoscopy was repeated on October 15 and still no growth was seen. As the sputum remained at one to three ounces a day and was still offensive and pyrexia continued, and the radiographic appearances remained unchanged, operation was advised The chronicity and extent of the lesion excluded external drainage.

At thoracotomy on October 22 an obvious growth was found encircling and infiltrating the left upper lobe bronchus; a dissection pneumonectomy was done. The opacity was due to an obstructed septic pneumonitis and the abscess was a chronic foetid one secondary to the bronchial carcinoma

tion is difficult or impossible In these cases, as was mentioned earlier, the resemblance to a chronic, spreading, or multifocal, non-specific suppurative pneumonitis may be very c
on the search for a definit
abscess and for reluctance
primary suppurative pneumonitis with abscess formation

Case 3

the apical segment of the left lower lobe At bronchoscopy on February 22 no growth was seen.

His condition continued to deteriorate, fever continued and large quantities of purulent sputum were raised There was little or no response to full courses of penicillin and sulphadiazine, in spite of blood transfusions his anaemia persisted A second bronchoscopy still showed no growth

In spite of his extremely poor general condition it was decided to perform thoracotomy, and after a period of high calorie-protein diet and further blood transfusions he was ready for thoracotomy by mid-April The opacity in the left lower lobe had cleared considerably although a number of thin-walled, empty abscess cavities remained A pre-operative radiograph showed, however, that a large opacity had suddenly appeared in the left upper lobe, the abscess cavities in the lower lobe remained (Figure 47*b*), the sputum was now only two ounces and he was almost afebrile

performed without event Amongst a number of enlarged glands in the hilum was one larger and firmer than the others. Section of the lung revealed the appearance shown in Figure 48 The lower lobe contained a number of empty abscess cavities with thin, shiny white walls, either epithelialized or covered with inert hyaline material The upper lobe was occupied by

Here, then, is an example of an unusual type of carcinoma which manifested itself for many months, not in virtue of the primary growth, but from the secondary abscess formation in the lower lobe. The inflammatory element in the lower lobe had almost cleared, except for the residual chronic abscess



FIG 47 Radiographs of Case 3, W S, aged 60
FIG. 47*a*. Abscesses of the apical segment of the left lower lobe, the upper lobe is aerated
FIG 47*b* The abscesses are now represented by thin-walled, empty cystic spaces with scarcely any surrounding pneumonitis The left upper lobe, however, is opaque from a primary carcinoma The original lower lobe abscesses were secondary to this growth The specimen is shown in Figure 48.

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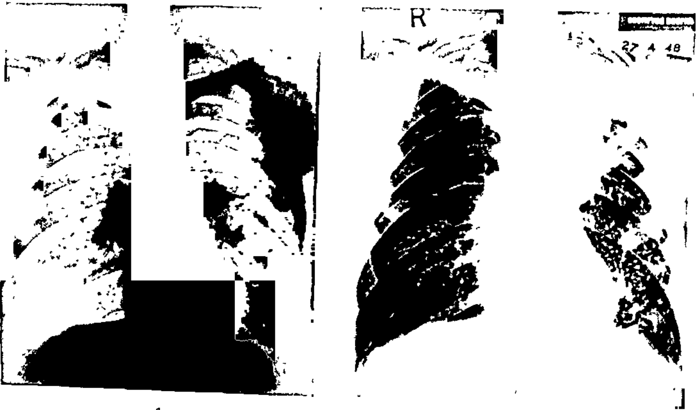
FIG. 48. Photograph of the excised lung from Case 3 (Figure 47). The empty, thin-walled, cystlike spaces in the lower lobe are well shown. There is no growth in the lower lobe, the upper lobe contains a primary growth.

the time in this case and three careful bronchoscopies had been done, it was not possible to identify growth. Even at thoracotomy the condition was thought to be inflammatory, and it was only by microscopy that the correct diagnosis was revealed.

TREATMENT

Experience with these cases shows that satisfactory treatment is, unfortunately, in most cases even more difficult than correct diagnosis. To a certain

health that has followed upon the continued suppuration and, coupled with a solid, adherent 'frozen' lung, may make an attempt at radical removal unlikely to succeed; especially if, as is often the case, the patient is elderly and frail, and in spite of the fact that the growth may still not have metastasized.



a *b*

Fig. 47 Radiographs of Case 3, W S, aged 60.
Fig 47*a*. Abscesses of the apical segment of the left lower lobe; the upper lobe is aerated.
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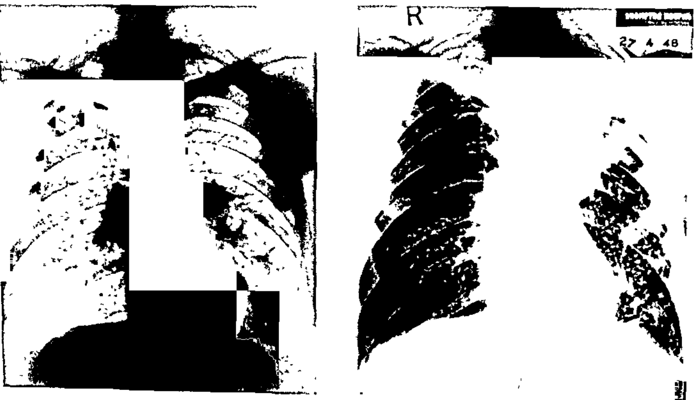


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Treatment

Experience with these cases shows that satisfactory treatment is, unfortunately, in most cases even more difficult than correct diagnosis. To a certain extent this is linked with the difficulties of diagnosis, because only too often it is found so much valuable time has been lost that the condition has become inoperable. Not infrequently the deciding factor is the poor general state of health that has followed upon the continued suppuration and, coupled with a solid, adherent 'frozen' lung, may make an attempt at radical removal unlikely to succeed; especially if, as is often the case, the patient is elderly and frail, and in spite of the fact that the growth may still not have metastasized.



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excessive lung damage, or increase of his risk of dying. Clearly it is proper, in assessing the need for surgical interference, to take into account the increased risk and increased pain and suffering which an operation itself may entail. Whereas with a relatively superficial abscess in a site elsewhere in the body this risk is negligible, it is obvious that the external drainage of a lung abscess involves a greater risk. A balance must, therefore, be struck in each case between the risk of further delay and the risk attached to the operation itself The decision may be a very difficult one and demands considerable experience with the disease.

Furthermore, suppuration in other parts of the body may have become so extensive or have caused so much tissue destruction that simple drainage may be inadequate Amputation of a limb or excision of the whole organ (e.g. nephrectomy, cholecystectomy, etc.) may be the treatment of choice. Similarly, in dealing with lung abscess it may be better to perform a radical operation (lobectomy or pneumonectomy) rather than simple external drainage

Once more it must be emphasized that 'lung abscess' is not an entity, and in treatment a complete diagnosis of the primary cause and nature of the lung suppuration in each individual case is of first importance; for what applies to one variety may not be applicable in another. It is hopeless to approach the treatment of every case in the same way. There are, for instance, wide differences in the natural course of the illnesses caused by the acute specific abscesses such as the staphylococcal ones and by certain of the acute fuso-spirochaetal variety The prognosis also may be quite different between an abscess caused by a remediable local cause such as a benign bronchial obstruction, and an abscess secondary to a bronchial carcinoma. There is no need, at this time, to recapitulate what has already been said about the differential diagnosis of the different types of lung abscess; it is only necessary to emphasize again the existence and importance of these different types

The Expectant Management of Lung Abscess

The term 'expectant management' is used partly for convenience and partly to avoid the term 'medical treatment' The treatment of suppuration and abscess formation in any part of the body is essentially surgical; lung abscess and lung suppuration should be considered essentially as a surgical condition just as much, for instance, as acute appendicitis, cases of which are no longer admitted to the medical wards as they were a generation ago It is true that as a result of the historical development of medicine and surgery the chest has long [illegible]
of the surgical tre[illegible]
diagnosis led to t[illegible]

CHAPTER IX

THE TREATMENT OF LUNG ABSCESS

A CERTAIN amount has necessarily been written about treatment in the preceding chapters; it now remains to consider this problem more comprehensively.

The subject is a difficult and controversial one, largely because the condition is still too little understood. It has been emphasized that lung abscess is not an entity but includes a variety of conditions; it is clear, therefore, that it is not possible to dogmatize on treatment in every case; it is unwise to argue from the particular to the general. On the other hand, there are certain general principles that apply to all lung abscesses and it is desirable to consider these before we particularize. In dealing with any difficult and complex subject it is best first to try and rationalize it; in considering the treatment of lung suppuration and abscess, we can do this by appreciating that the treatment needed is, fundamentally, no different from that needed for a suppurative process anywhere else in the body. Certain modifications may be required as a result of special local factors or because of a special type of suppuration; just as modifications may be called for as a result of local features in other parts of the body.

The generally accepted basic treatment for suppuration or abscess in any part of the body is to encourage its resolution or maturation by rest, chemotherapy, and antibiotics, and various simple measures such as heat. By this means it is hoped that, if the inflammatory process does not resolve, the [illegible] spontaneously and cure itself. Even [illegible]

having [illegible]

too early, and the prevention of undue local tissue destruction or [illegible], prolongation of pain and disability if it is delayed too long. Similarly, even if the abscess has begun to discharge, drainage may be inadequate, and it is for the surgeon to advise upon the provision of adequate drainage.

Fundamentally, the management required for lung suppuration and lung abscess is the same as this. By the exhibition of rest, chemotherapy, and antibiotics, and various simple physical methods we aim to encourage natural resolution or, if this fails, spontaneous evacuation of the abscess. It is far better for a lung abscess to heal, if it will, without recourse to an operation; always providing that the withholding of surgery does not expose the patient to unnecessary prolongation of suffering and disability, to the danger of

excessive lung damage, or increase of his risk of dying. Clearly it is proper, in assessing the need for surgical interference, to take into account the increased risk and increased pain and suffering which an operation itself may entail Whereas with a relatively superficial abscess in a site elsewhere in the body this risk is negligible, it is obvious that the external drainage of a lung abscess involves a greater risk. A balance must, therefore, be struck in each case between the risk of further delay and the risk attached to the operation itself The decision may be a very difficult one and demands considerable experience with the disease.

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medicine. To-day it is still usual to find that most physicians understand more about chest diseases than most surgeons, and it is right and proper that, in these circumstances, the physician should be the adviser. If the physician is also a specialist in chest diseases then there is no question of the value of his advice and opinion, and he should certainly be the governor of treatment if his surgical colleague is not himself a chest expert. The specialist chest surgeon, also, should welcome the help and guidance of his physician colleague in these matters; he would be most unwise not to do so.

At the same time, when a surgeon has a proper knowledge and experience of chest diseases the management of a lung abscess rightly falls within his province and not, primarily, within that of the physician. It is true that the time has not yet come when lung suppuration and lung abscess automatically fall to the care of the surgeon as is the case with suppuration and abscess in almost all other parts of the body; but as the surgery of the chest becomes sufficiently widely established, lung abscess will be similarly accepted as a surgical condition.

It is, therefore, more correct to describe the non-operative-management of lung abscess as 'expectant management'; it can be supervised with equal efficiency by either physician or surgeon; the governing factor is the possession of the proper knowledge and experience to decide when such expectant management has ceased to be useful and operation is needed.

A most important guiding principle in the approach to the treatment of lung abscess is to remember that *it is always a serious condition.* The knowledge that in a proportion of cases there is a strong tendency towards spontaneous resolution has engendered a complacent attitude; the first and chief teaching is often that a lung abscess is best left alone as it is more likely than not to heal by itself. This can be a most dangerous policy and cannot be upheld by a critical study of results. Even when apparent clinical healing has occurred a serious or fatal complication may present. An apparently small abscess producing a minor illness may suddenly give rise to a cerebral abscess. The proper attitude should always be that it is always a serious condition until complete clinical and radiological cure has been established. From an analysis of actual figures given later (page 172) it will be seen that only some 20–40 per cent of cases are cured by expectant management alone.

Expectant management consists of maintaining and increasing the bodily powers of resistance and encouraging resolution or drainage by natural means. Rest in bed, provision of adequate fluids, calorie, protein, and vitamin intake, the correction of anaemia, and the exhibition of appropriate chemotherapy and antibiotics cover the first part. Various forms of physical treatment complete the régime.

Rest in bed is self-determining in many cases owing to the degree of illness present, but it is by no means uncommon for a patient to attend at an out-

patients' clinic for consultation and it is found that his observation and treatment are ambulatory. It is quite indefensible to treat a patient suffering from a lung abscess as an out-patient; he should always be admitted to hospital It is as well to repeat, the condition is always serious and its deadly nature is often suddenly and dramatically manifested when it seems to be pursuing a benign and favourable course.

In a disease such as lung abscess, in which abundant and prolonged suppuration may occur, it is particularly important to ensure a high calorie-protein intake, and to guard against secondary anaemia. A blood-count should be done at least once a week (more often, of course, if sulphonamides are being used). It is, unfortunately, only too common to find that a patient who has been ill for several weeks is wasted, dehydrated, and severely anaemic, and that no effort has been made to prevent or correct these changes.

Chemotherapy and antibiotics

Chemotherapy has saved many lives and has cured many lung abscesses; penicillin in particular has proved invaluable. On the other hand, it must be remembered that chemotherapy is a double-edged weapon and, if persisted in when drainage of a collection of pus is needed, may be harmful and not helpful The incorrect and inadequate administration of sulphonamides needs only mention as it applies to all inflammatory diseases Smith (1948) thinks that sulphonamide therapy for the fuso-spirochaetal type of infection has been harmful in an indirect manner in that 'patients in the early pneumonic stage of the disease usually show marked temporary improvement which encourages continuation of the therapy; then later they develop necrotic abscesses which will no longer respond either to sulphonamides or penicillin, and require surgical treatment '

In cases of lung suppuration due to specific organisms which are penicillin-sensitive, such as the staphylococcus, penicillin may be dramatically successful In the chapter on staphylococcal lung abscess examples were given of immediate response to the exhibition of sulphonamides. In most other cases it is better to combine penicillin with a sulphonamide, such as sulphadiazine In many cases of lung suppuration the dose of penicillin should be at least 1,000,000 units intramuscularly each day for, if necessary, three weeks. The sulphonamide will, of course, have to be interrupted during this time. Some authors have written enthusiastically of over 90 per cent of cures in fuso-spirochaetal lung abscess by this combination (e g. Stivelman and Kavee, 1947) As was emphasized in the chapter on foetid lung abscess, the presence or absence of a lung slough is of paramount importance; if one is present, rapid and complete resolution is unlikely without operation. It is difficult to believe that the incidence of slough formation is less than 10 per cent in any long series of cases.

Smith (1948) analyses 60 cases treated with penicillin collected from the literature, including his own, and states that the results are very encouraging; 'for the early incipient stage of infection, penicillin is certainly the drug of choice, but it is not effective in the chronic cases although the patients may improve to a point where they are better surgical risks' Of the total of 60 cases, 10 died (16·7 per cent), 38 were well (63·3 per cent), and 12 remained chronic (20 per cent).

Sutherland and Grant (1950), in an enthusiastic report of the benefits of penicillin therapy in 32 consecutive cases of acute lung abscess treated over a period of three years, announce that 18 were cured (56·25 per cent), 1 died (3·1 per cent), and 13 failed to resolve completely (40·65 per cent); 7 of these latter were submitted to external drainage.

It is often found that chemotherapy is said to have been used where a full inquiry shows that it has not been applied adequately and efficiently. If it is decided to continue expectant management of a lung abscess which has not so far responded to treatment, then there is no doubt that a full course should be given The response even in a grave case may be most gratifying.

Case 1

Mrs D E, aged 49, had suffered from a productive cough since childhood, in 1916 she had a left-sided pleurisy and in 1920 left-sided pneumonia. Apart from her usual cough she was well until February, 1948, when she had two small haemoptyses; radiographs at that time suggested old bronchiectasis of the left lower lobe with a small area of consolidation in the lateral portion of the anterior segment of the left upper lobe; this appeared to be a spill-over lesion from the chronically infected left lower lobe.

She was admitted to a hospital on February 6 with fever and left-sided pleural pain, she was treated with sulphadiazine. Clear fluid was aspirated from the pleura on two occasions; fever and illness continued A bronchoscopy on February 24 revealed no sign of growth. She was given 40,000 units of penicillin four-hourly for a few days. The sputum increased to six ounces of thick pus and was occasionally blood-stained.

On May 24 one of the left lower ribs was resected and an 'empyema' cavity was said to have been found; a biopsy was taken of the wall of this cavity and was said to show growth.

She was admitted to the Brompton Hospital in June, 1948, desperately ill, running an irregular high fever, very wasted, and coughing up five to ten ounces of purulent sputum. Bronchoscopy showed infection only. A small subcutaneous fluctuant area near the site of the old empyema operation was incised and pus, sterile on culture, was obtained Radiographs showed a dense opacity occupying the greater part of the left lower lobe and part of the left upper lobe, lipiodol injected into the sinuses ran into a cavity in the apical segment of the lower lobe.

She now became even more gravely ill and the sputum increased to as much as twenty ounces a day She was clearly coughing up the contents of several abscess cavities in a large area of suppurative pneumonitis. Actinomycosis was considered a possible diagnosis and it was noted that she had never had effective chemotherapy. Accordingly she was given intramuscular penicillin, 1,000,000 units a day; the effect was immediate and dramatic. Within four days the sputum had fallen to five ounces a day and within ten days had fallen to half an ounce and continued at this level until her discharge; the temperature also fell to normal and remained so Penicillin was given for six weeks

The biopsy material taken before admission to the Brompton Hospital showed *typical actinomycotic infection* with numerous granules. She was discharged on July 10, having gained over a stone in weight, the empyema sinus was healed and much clearing of the opaque area in the left lung had occurred. It is almost certain that she will need lobectomy at a later date.

It should be remembered that amoebic lung abscess may be met with and will respond favourably to emetine. In streptomycin we have an agent that may help in cases of Friedlander abscess or those due to other specific organisms insensitive to penicillin. Aureomycin has lately come to our aid. No doubt our armamentarium of chemotherapeutic and antibiotic drugs will increase with correspondingly favourable influence on many more cases of lung abscess hitherto resistant.

Penicillin may also be given by inhalation if desired, although there is little evidence that it is of any use in lung abscess.

In addition to its parenteral use, penicillin can be used topically. In the past various antiseptic substances, such as gomenolized oil, have been injected into the region of the abscess bronchoscopically, but with little obvious curative effect. In penicillin we possess a much more potentially active and useful substance for local instillation. It may be applied directly through the bronchoscope, although most patients will soon become intolerant of passage of the instrument sufficiently often to be of value. Métras and Lieutier (1947) have introduced some special curved catheters with a radio-opaque tip which can be guided quite simply and, under radiographic control, accurately into any one broncho-pulmonary segment (Figure 51). Once the catheter is in position the patient is placed so that the affected segment is dependent and 100,000 units of penicillin in 5 ml. of water are injected down the catheter; the patient remains in this position for twenty to thirty minutes. He may tolerate the passage of the catheter (which is done under local analgesia) every two days, six to eight treatments are usually desirable. Métras and Lieutier claim good results from this method, and even when cure does not follow they state there has been considerable improvement. Actually the patient may soon become intolerant of the catheter and it may not be possible to give a full course. Moreover, if a slough is present or if drainage is imperfect from mechanical factors, or if the disease is scattered, multicentric, or becoming chronic, it is unlikely that a high percentage of successes will be achieved. There is no doubt, however, that the method is worthy of a full and wider trial, if only in selected cases.

Postural drainage

The chief physical method at our disposal in expectant management is postural drainage. The guiding principles of this were ably laid down by Nelson (1934), and do not need elaboration here except to stress that postural drainage does not consist simply of 'tipping.' In abscess of the lateral areas,

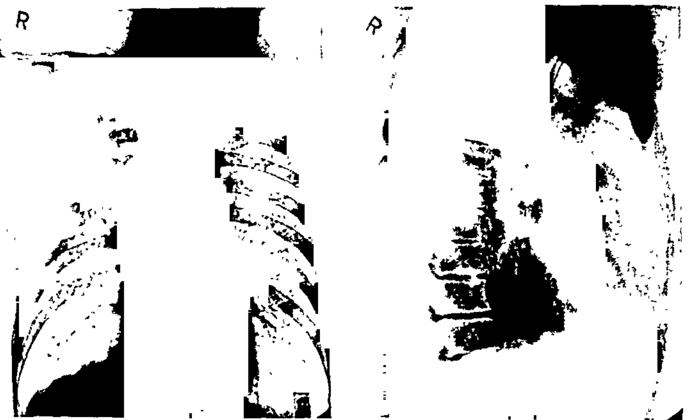


Fig. 51. To show the use of a Metras catheter for instillation of penicillin into an abscess of the posterior segment of the right upper lobe.
Fig. 51a. Shows much of the catheter hidden in the mediastinal shadow, although the opaque tip is visible
Fig. 51b Shows the whole course of the catheter and that it has been passed exactly into the correct bronchus.

for instance, the patient should be lying on his side; for abscess of the apical segments of the lower lobe he should be prone; for abscess of the middle lobe he should be placed on his back with the foot of the bed slightly raised. The proper position for postural drainage can be prescribed only after a careful study, by *lateral* as well as postero-anterior radiographs, of the segment or segments involved and the direction of the draining bronchus. Occasionally the patient finds he coughs up sputum more readily if he lies or sits in some posture other than the one which would appear to be the most favourable; clearly such a position is to be encouraged. These vagaries of postural drainage are probably due to the actual position of the orifices of the draining bronchi within the abscess cavity itself.

Postural drainage should be carried out for as many hours a day as the patient can tolerate it; it is useless to use it for twenty to twenty-five minutes once or twice a day. With encouragement it will be found that longer periods can be tolerated each day until most of the waking hours, apart from meal and toilet times, are devoted to it. The position should be retained, if possible, for sleeping. It is usually undesirable, and often cruel and harmful, to make a patient hang out of bed with his head reaching towards the floor. If 'tipping' is necessary it is less crude either to raise the foot of the bed on a chair or high blocks, or to use a simple frame, or a Nelson bed if one is available.

Postural drainage may be usefully supplemented by vibration, hacking, and clapping applied intelligently and not too severely. Combined with chemotherapy it is often of great help in aiding spontaneous resolution of a lung abscess. It is difficult to assess accurately the part it plays as it is necessarily only one feature in the whole régime of expectant management.

The only other method of physical treatment that needs mention is short-wave diathermy, which has achieved a certain popularity although it is difficult to show that it exerts any markedly beneficial action.

Bronchoscopy

Although bronchoscopic therapy is an operative manipulation, it is properly considered here as it is an attempt at conservatism and so forms a part of expectant management. Actually its greatest value lies in investigation and diagnosis rather than in treatment. By its use a primary causal intrabronchial lesion may be recognized or excluded, and it is of great value in aiding or confirming the anatomical localization of the abscess.

It is sometimes stated categorically that every patient with a lung abscess should be bronchoscoped. Although this is in general true, at any rate for diagnostic purposes since no case of lung disease can be said to have been properly investigated without bronchoscopy, it is difficult to subscribe unreservedly to the statement. Often the antecedent history and the clinical



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picture are so precise that the diagnosis can be reasonably accepted; moreover, progress may be so satisfactory that insistence on a bronchoscopic examination is *over zealous; conversely*, it may be obvious that operation is so urgently needed that bronchoscopy is both a waste of time and an added burden to the patient.

A great deal has been written about the therapeutic value of bronchoscopy, especially by the Philadelphia School of bronchoscopists, but it is not proposed to conduct a close analysis of these contributions. In general, it is fair to say that striking improvement following bronchoscopic treatment is too infrequent or unconvincing to have led to its wide or confident adoption. It certainly affords relief in a certain number of cases, but however fairly and conscientiously one applies it, one inevitably realizes its limitations. When the local morbid anatomy is considered dispassionately, it is indeed difficult to see how bronchoscopic aspiration can be of real help in many cases of lung abscess. The hindrances to healing lie chiefly within the cavity and consist of the lung slough and thick, semi-solid debris, aided by swelling and occlusion of the relevant bronchi opening into it. In chronic cases, satellite abscesses and chronic fibroid changes in the walls and adjacent lung are additional unfavourable factors. The statement that the bronchoscopist can remove or push aside granulation tissue, dilate narrowed bronchi, and insert his sucker-tube directly into the abscess cavity gives a far too favourable picture. Even if it were possible to do this on more than the rarest occasions, it would not remove the material or alter the local conditions, which are the real cause of the delay in healing It is probable that the actual therapeutic value of bronchoscopy in lung abscess is due as much to the stimulation of coughing as to the direct aspiration of pus, except in the rare cases (usually in the lower or middle lobes) when the sucker can be manipulated into the abscess.

Penicillin may be instilled at bronchoscopy, but, as pointed out by Métras and Lieutier, the usual dorsal position used for bronchoscopy does not favour retention of penicillin within the affected segment unless a dorsally-placed one, such as the apical segment of a lower lobe, is affected.

The figures given by the advocates of therapeutic bronchoscopy do not support their contention of its great value. Flick, Clerf, Funk, and Farrell (1929) report 172 cases of lung abscess in 121 of which bronchoscopic treatment was used; the results were:

Cured	66 (54 per cent) !
Improved	16 (13 per cent)
No improvement	8 (6 per cent)
Referred to surgeon	28 (23 per cent)
Died	3 (2·4 per cent)

The recovery rate was, however, 70 per cent in those patients who had had the abscess less than three months.

Lueth (1935) reports 37 patients of whom 24 recovered, 8 died, and 5 became chronic.

Arbuckle's series of 43 patients (1940) is conspicuous in containing no deaths; 19 patients were cured, 4 were improved, and 20 were no better.

In this country, Scott-Pinchin and Morlock are the only workers to report any lengthy series, and in their report on 55 cases (1935) they reject 8 as too advanced for useful treatment and submitted 2 to operation at once. The remaining 45 were treated by bronchoscopy, and of these 3 died and 7 were referred for operation. The fate of the remaining 35, however, is not clear from their report; one is left to assume that they were improved or cured, but there is no clinical presentation of their course

Allen and Blackman (1936) collected 2,114 cases of lung abscess, of which 650 were treated by bronchoscopy. The results in these were as follows:

Recovered .	61 per cent
Died .	6·5 per cent
Became chronic .	32·5 per cent

The Operative Treatment of Lung Abscess

It will be generally agreed that the happiest course for a lung abscess to follow is to heal under expectant management and without the need for an operation. On the other hand, a warning has been sounded against complacent acceptance of an almost totally conservative attitude towards all cases just because a number of abscesses may resolve without operation We must have the wit to recognize when the clinical course is proceeding favourably and to leave well alone, it is also very important to be able to recognize unfavourable features and to cut short a dangerous process by operation. The decision may be an easy one; it is often difficult and demands the nicest judgment

In Chapter IV it was stated that it was not possible to agree with the generalization expressed by Neuhof and Touroff that there is a much greater tendency towards spontaneous cure in the non-foetid abscess. While it is true that the non-foetid group includes a number of the acute specific types of abscess in which there is a marked tendency to resolve under expectant management, especially with modern chemotherapy, the need for surgery often remains This is shown by the following figures which indicate a high incidence in both groups of non-resolution and chronicity demanding operative treatment.

TABLE XIII

ACUTE LUNG ABSCESSES OCCURRING IN A SERIES OF 318 CASES OF LUNG ABSCESS (EXCLUDING MALIGNANT ONES) SEEN IN THE YEARS 1942–50

	Total	*Spontaneous resolution*	*Required operation*	*Died*	*Died after operation*
Acute foetid	61	37 (60%)	20	3	3
Acute non-foetid	81	56 (70%)	16	6	4

It will be seen that the difference in favour of the non-foetid group is relatively slight and that it would be most unsafe to proceed on the assumption that a non-foetid suppuration or abscess is *not likely to need surgery*.

The most important cause of non-resolution is the presence of a slough, and *this is more likely to occur in the foetid group*, although not every foetid abscess contains a slough and spontaneous resolution occurs in about 40 per cent. Other factors make for *delayed resolution and these act in virtue of producing ineffective drainage*; they are the small size of the draining bronchi, oedema, congestion and swelling of the bronchi, valvular or semi-valvular *arrangements*, unfavourable localization within the cavity, *thickness* of secretion, presence of blood-clot, etc., etc. The longer the abscess smoulders on, the more do secondary fibroid changes, *rigidity of the walls*, contracture of bronchial orifices, and development of satellite abscesses make spontaneous *resolution less and less likely. The longer the process continues, the greater* is the risk to life, of extension of the disease, and of permanent secondary changes. Touroff and Moolten (1935) have done well in pointing out that chronic pulmonary suppuration, once *established*, never resolves, and usually proves fatal within three years; in this feature it assumes the seriousness of a malignant process.

It is, unfortunately, only too common to see patients who have been allowed *to drift into a state of chronic lung suppuration which could have been cut* short by operation many months before with the saving of much suffering and economic loss. Even if life can be saved in such cases it must be at the sacrifice of a lobe or whole lung; *if operation is undertaken at the right time there is* no reason why any permanent lung damage, or only the barest minimum, should remain. One of the commonest questions asked is, 'How early do you like to operate?' The answer must unfortunately always be qualified by *stating that it is far too uncommon to see a case* in which there is the opportunity of operating at the ideally early time; it is far more common for a case to be referred when it has already reached a stage of chronicity.

One of the practices *most responsible for this is the teaching*, still prevalent, that operation should not be contemplated until the abscess has been allowed

at least six weeks in which to heal on expectant management. This can be a most pernicious doctrine and is responsible for many deaths and much unnecessary suffering and disability. It may, of course, be quite sound to observe a case for six weeks providing it is pursuing a steadily favourable clinical and radiological course, but in its worst form this policy condemns a patient to a stereotyped waiting time of six to eight weeks irrespective of the unfavourable course of his illness and the unpleasantness and danger he undergoes. Nowhere else in the body would such a thoroughly unsurgical policy be accepted, and there is no justification for it just because a lung abscess is deeply seated and hidden. No patient would tolerate being told that the abscess on his thigh or arm was to be left for six weeks, without surgical relief, however much suffering, pain, and danger to life resulted; he would demand relief by operation, and we should advise him accordingly in the deeper acute lung abscess Indeed, it is our duty to point out to him that relief is obtainable by operation. Far from operation being dangerous, it cuts short his illness, allows his lung to heal rapidly with the minimum or complete absence of permanent damage, and saves him from the dangers of chronicity. The poor results that do often follow operation for lung abscess are due not to surgery, but to surgery employed too late. It is fair to no one to submit for operation a patient who has been allowed to drift for weeks or months into a wasted, toxic, anaemic state, and with dangerous, irreversible changes already present in the lungs. Experience with lung abscess teaches that an acute lung abscess is no longer 'acute' after six weeks; it has then reached the chronic stage and is usually unsuitable for a simple external drainage operation.

A recent paper by Sutherland and Grant (1950) claims that there is no place for surgical drainage of acute lung abscess 'They will heal under intensive treatment, and local complications, if any, will be treated by resection.' From their study of 32 consecutive cases treated over a period of three years they state: 'It seems that penicillin and postural drainage can completely cure lung abscess.' It is certain that abscesses *can* be cured in this way; their wording and theme implies, however, that the rate of cure is high, whereas only 18 were cured (56 25 per cent).

The enthusiasm for the results in this series illustrates an attitude that has grown up since the improved results following intensive penicillin therapy. The ultimate need for lobectomy or pneumonectomy is dismissed as 'treatment of a local complication.' This is a flattering, but at the same time belittling, description of removal of a part of, or the whole of, a lung. It typifies a policy that is content to continue with penicillin therapy until chronic abscesses have developed and then to deal with them by major resection. A number of authors have drawn attention to the weakness in this argument, and Klepser and Davis (1950) rightly comment that 'by controlling

toxic symptoms and eliminating the foul odour, the antibiotics actually foster procrastination of necessary surgery,' and 'the present trend is towards over-treating with antibiotics and then resecting the abscessed lobe when it is obvious that conservative measures have failed.'

While sympathizing with the desire to avoid external drainage, with its drawbacks and dangers, especially in chronic cases, while agreeing with the great benefits conferred by intensive penicillin and chemotherapy, and while approving the good results of resection as opposed to external drainage in chronic cases, it is difficult to support the complete rejection of external drainage in the treatment of acute lung abscess. It is true that the operation is seldom done to-day and that resection in some form is the commoner practice, but we still have to ask ourselves whether some of these resections could have been avoided if early drainage had been instituted and penicillin not continued until chronicity was evident.

It is, indeed, a bold step to reject completely the time-honoured surgical principle of external drainage of an acute abscess that is not speedily resolving; even if its more troublesome acute manifestations have been damped down by the powerful action of penicillin. It is a weak argument that if chronic suppuration becomes established it can be dealt with by removing part or all of the lung. If the cavity contains a lung slough (the full importance of which was stressed in Chapter II) it is inevitable that it will proceed to chronicity if the patient survives and expectant management alone is used. Early external drainage and removal of the slough offers speedy cure without resection; the chance of complete recovery being, of course, enhanced by the concomitant exhibition of penicillin The frequent incidence of slough formation in lung abscess is a highly significant feature in this problem.

On looking back over one's cases, many come to mind in which a rapid and very satisfactory recovery with no loss of lung tissue and no residual damage followed external drainage of an acute abscess that was not progressing favourably and was threatening life. These patients are surely better off than if they had lost a lobe or a whole lung. Moreover, a patient may be quite unfitted to withstand lobectomy or pneumonectomy owing to age, frailty, emphysema, or some other factor causing gross interference with respiratory function.

It will be seen from the argument and recommendations made later that the advantages and greater safety of definitive resection as opposed to external drainage are fully endorsed in *chronic cases*. It is agreed that the improved results with the intensive use of antibiotics make external drainage but seldom needed. It is, however, not possible to accept the suggestion that external drainage for an acute abscess is obsolete and that the only surgical measure to be considered is radical extirpation in the chronic phase. Moreover, the high mortality and morbidity of external drainage occurred in the pre-

nicillin era, and it is yet to be shown that they are not also lessened just as section has been made so much safer by the antibiotics.

If an abscess is not draining adequately by itself, then it should be drained surgically. The dictum '*ubi pura, ibi evacua*' applies as much to the lungs as anywhere else in the body; in fact, the dictum is best strengthened by the rendering '*ubique pura, ibi evacua*,' 'wheresoever there is pus, drain it.' In the past the main objection to early drainage has been a fear of the risks of the operation. To a certain extent this is justified if the abscess is approached without full realization of the surgical anatomy and the importance of exact anatomical localization. The fundamental importance of this has already been stressed and the whole question of the surgical anatomy and operative approach described and discussed (Brock, 1945). The fear of surgery should no longer be an argument against early operation in properly selected cases. As soon as one is satisfied that an acute lung abscess, foetid or non-foetid, is not making satisfactory and uninterrupted progress towards recovery it should be drained. Occasionally this decision may be made on sight; more usually the case can be assessed only after being watched for a few days while the expectant measures already described are used It must be stressed that the time of waiting should be measured in days, not weeks. When there is little or no clinical or radiological improvement, or even deterioration, the decision should be easy; external drainage should be carried out forthwith Once the decision has been made the operation should be done at once. Difficulties in the decision arise when there is some improvement and one may be led to delay longer, a decision that may or may not be justified by the event

The assessment is made easier if the whole picture is resolved into three components In its worst form a lung abscess causes (i) general illness as shown by fever, toxaemia, etc., (ii) production of purulent sputum, and (iii) a radiological opacity or frank abscess cavity The general disturbance may lessen or disappear, but productive cough and radiological changes may persist, general health may appear satisfactory and sputum is no longer raised, but radiological changes are still present It should be clearly understood that unless all three manifestations—general disturbance, cough with sputum, and radiological changes—are no longer present, the state of affairs is not stable and is not satisfactory It is only too common to find that a patient has been observed for many weeks or months and has then been discharged from hospital because fever, cough, and sputum have abated, and in spite of the fact that an opacity or fresh abscess cavity persists; these patients almost invariably return with recrudescence of symptoms which not infrequently prove fatal

Unless there is steady and undoubted improvement in all the three pertinent features described, the process should be cut short by operation. The most

decisive of these things is often the radiological appearance, and this is the one only too often glossed over. For instance, it is seldom appreciated that the persistence of a cavity containing a fluid level is itself direct proof of imperfect drainage. In an earlier essay the danger was stressed of assuming that a homogeneous opacity does not contain an abscess cavity; such an opacity may conceal an acutely blocked cavity or one that is full of inspissated solid material, perhaps *quite symptomless* at present, but possessing all the dangers of a time-bomb.

Case 2

Mrs E.B, aged 45, underwent a cholecystectomy under general anaesthesia in August, 1946 She was very ill after the operation and, about three weeks after it, developed a cough with bad-tasting sputum, on the day after she went home she had 'pneumonia and pleurisy.' The chest was not examined by X-rays at this time. Three months later she again coughed up purulent sputum which had a bad taste; she was never really well and had occasional bouts of pyrexia diagnosed as influenza.

In the following May she became worse and a radiograph of her chest (the first one done)

well since she had had a course of intramuscular penicillin She had, moreover, recently had a bout of fever and was coughing up a small amount of purulent sputum; most significantly, in addition to persistence of the opacity in the posterior segment, there was a new small abscess in the lateral part of the anterior segment with a definite cavity.

Bronchoscopy was essentially negative except for a little muco-pus in the right bronchus;

She still protested that she was quite well and had only
however, running a niggling temperature of 99° *and there was no radiological improvement*

It seemed clear that the opacity in the right upper lobe must contain a blocked cavity and was not just an area of 'unresolved pneumonia.' Lobectomy was advised but she preferred to wait longer.

By mid-November, 1947, fifteen months after the onset of the abscess, *she said she felt very* ... and she looked well. She had no symptoms except an occasional discomfort in

The right upper lobe was removed by dissection on November
was almost completely fused with the upper lobe it had to be removed as well; healing was uneventful and she was discharged three weeks later; she has remained very well since.

The specimen (Figure 52) *shows that the opaque area in the right upper lobe consists of* an area of chronically inflamed, fibrous lung enclosing an irregular abscess cavity which is completely full of semi-solid, inspissated, purulent, and necrotic material. Although for the time it was almost silent, this blocked cavity might at *any moment* have burst into activity and proved fatal.

Difficulties begin to arise in deciding for or against operation when there is improvement followed by relapse. For instance, after a week of expectant



FIG 52 Photograph of operation specimen from Case 2 The posterior segment of the upper lobe contains an irregular, chronic abscess cavity surrounded by chronically inflamed lung tissue and completely full of purulent necrotic material

management there may be improvement in all three features and then, two weeks or so later, fever, cough, and sputum increase. It may be decided to watch for a few more days, and it may well be that after one such relapse steady improvement follows. Unless improvement occurs soon, operation should be advised, and certainly if the illness tends to niggle on or if further relapse occurs Unless a firm decision is made, the weeks soon slip by, chronicity occurs and all the dangers of the condition increase.

Often a relapse is caused by the occurrence of a new abscess in an adjacent or in a more distant segment or sub-segment. If this is so, then operation should certainly be done forthwith, for the very event has demonstrated the unstable and dangerous state of the primary abscess.

External drainage of lung abscess

External drainage of a lung abscess may be an easy and most satisfactory operation providing it is properly planned In Chapter III the pathology and morbid anatomy of abscess was described, and it was shown that with but few exceptions an abscess is formed in relation to a broncho-pulmonary segment and always presents on the peripheral or pleural aspect of the segment. Presentation on the costal pleura is commonest, but the presentation may be on the mediastinal, interlobar, or diaphragmatic pleura. The essential preliminary to an operation for external drainage is to localize exactly the

particular segment of lung involved and to assess the area of presentation. The earlier descriptions of broncho-pulmonary segmental anatomy (Brock, 1945) deal with this matter fully. In any case of doubt the 'spot' method of confirmation of localization (Rabin, 1941) can be used. One or two ml. of iodized oil and methylene blue are injected into an intercostal space over the presumed site of the abscess and lateral and postero-anterior radiographs are made; in this way the relation of the 'spot' to the abscess can be assessed and any adjustment made at operation, at which time the methylene blue serves as a guide.

The thoracic cage should be surveyed as the terrestial globe; the surface presentation of an abscess can be fixed upon it by careful consideration of 'latitude and longitude' as given by counting the ribs and measuring accurately from the meridians formed by the mid-line in front and behind. In this way the abscess can be exposed by resection of a short length (4–5 cm.) of rib It may at times be necessary to resect a segment of one more rib, but never more than this; the old 'blunderbuss' method by which long segments of several ribs were resected over where the abscess is thought to be is wholly bad; *it is crude and unnecessarily dangerous and destructive.*

If the anatomical localization is correct, a one-stage operation is possible in almost all cases, for the pleura will be found adherent over the abscess except when the chief presentation is interlobar, mediastinal, or diaphragmatic. In such an event a two-stage operation may be unavoidable.

The *operation should be conducted under local analgesia to avoid* the grave danger of spill-over infection. A short vertical incision is made down to the selected rib segment, which is then excised (Figure 53*a*). As soon as the rib bed is exposed, light palpation will at once give some indication of the correctness of the localization. If the abscess lies directly beneath the wound the pleura will be firm, thick, and opaque. *The intercostal vessels should be* under-run and parts of the intercostal bundles above and below are resected (Figure 53*b*); in this way a roughly square area of parietal pleura is exposed [illegible]

movement indicates obliteration. [illegible]
lung is firm and [illegible]
is eccentric and [illegible]
The greatest eas[illegible]
operative field; [illegible]
accuracy of approach that may be achieved.

If the pleura is free or only partly adherent, the whole question of the correctness of the operative approach should be reassessed; it may be that after a readjustment of the incision the abscess is correctly exposed. In some

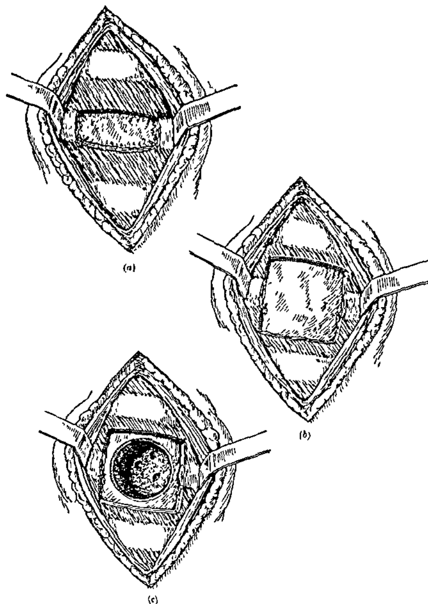


Fig 53 External drainage of a lung abscess

circumstances it is proper to open the pleura and insert a finger to assess the correct approach; the pleural defect can be closed by suture and any air or later fluid formation can be removed by aspiration. Although this is a method that is certainly justified if any further delay in opening the abscess is feared, it should not be used indiscriminately and certainly never to cover a loose and slovenly anatomical localization, as it is not without danger. If it is decided to delay the opening of the abscess until a second stage, a gauze pack should be inserted in the wound immediately outside the parietal pleura; it is a useful plan to free the pleura by careful blunt dissection all round the exposed area so that a wider surface can receive the pack. The pack should be dry, or if dipped in T.Iodi, it should be wrung out before insertion; if much iodine is in the pack it provokes too severe a reaction, much fluid is formed which may keep the pleural surface apart (in the basal regions) and thus defeats the purpose of the pack. The thin pleura may even give way and the pack enter the pleura. A radio-opaque marker should be incorporated in the pack and then, if postero-anterior and lateral radiographs are taken immediately after the operation, the position relative to the abscess can be ascertained before the detail is obscured by reactionary oedema. The wound should be closed by interrupted sutures; it may be re-opened for the second stage in seven to ten days.

If it is decided that the pleura is adherent, the presence of an underlying abscess can be confirmed by aspiration. My own preference is then to coagulate the exposed pleura and lung with diathermy and open into the abscess with a diathermy needle. If the localization has been accurate it will be found that the outer shell of lung is only 2–3 mm. thick, at the most it should be less than 1 cm.; if the abscess lies more deeply it will almost certainly be found that the approach to it is oblique.

The abscess is sucked dry and any sloughs or semi-solid material removed; touching the inner wall usually provokes coughing and much horrible debris and pus is squeezed out from adjacent smaller or larger loculi. The first opening should be only large enough to insert a bent probe or the finger in order to check its relation to the centre of the abscess so that it can be enlarged in the safest direction; otherwise, if the area of adherence is only partly overlapped (Figure 54*b*), the pleura may be inadvertently opened. The outer wall is now removed with diathermy as widely as possible, taking care all the time to avoid opening the pleura If there is any doubt it is better to be content with a small opening. The interior of the cavity should now be explored with the finger or inspected with a good light to note any loculi large enough to need drainage. It is sometimes necessary to open one or two quite large adjacent abscesses into the first cavity exposed.

If the pleura is inadvertently opened it should be closed by deep sutures; if possible a flap of intercostal muscle should be used to reinforce the closure.

It is best to complete the operation by inserting a light pack in the cavity; this may be dry, in which case the whole wound may be po with penicillin-sulphonamide. A single piece of dressing should be over the wound and pack and then firm strapping applied; more dre placed outside the strapping The advantage of this is that a firm sup given for coughing; a most important consideration.

After care

Intramuscular penicillin should be continued after the operation should also be taken to maintain a high calorie-protein intake and to the haemoglobin level, it is advisable to give ascorbic acid. The pack left unchanged for two to three days if it does not become offensive; the it will need changing daily It is a good plan to have retractors and a ma light ready so that the interior can be carefully inspected. The pack be inserted quite lightly; if it is packed in tightly it interferes with d and distends the cavity progressively instead of allowing it to contract A drainage tube at this time is dangerous, chiefly because of the da [illegible] ie risk of this a [illegible] 1 more efficientl [illegible] efficient draina penicillin, if the dressings continue to be offensive the smell can be co by including a 'charcoal sandwich' in the dressings, i.e. a layer of po charcoal between two layers of gauze

Usually the pack can be replaced by a tube after fourteen to twent [illegible]

rigid, and it must not be so long that during the act of coughing it d the lung. The tube should be left out as soon as the cavity in the obliterated; radiography after injection of opaque oil may be nee assess this

The danger of secondary haemorrhage is ever present, and indeed tutes one of the greatest risks of the operation If bleeding occurs the should be taken to the operating theatre so that the wound can be in efficiently under a good light, it is wrong to tinker and temporize The bleeding may be from the lung, and if small in amount can o controlled by diathermy and a pack It is more likely to be from an costal vessel, and it is imperative that this be securely controlled by If bleeding is severe and recurrent and comes from the lung, an impossible situation may rapidly develop because of the rapid deteri of the patient If his condition permits it lobectomy or even pneumon

may be the only solution; often his low condition enforces conservatism and blood transfusions in the hope that the process will subside by itself.

Watch should be kept for a pleural effusion which may occur even if there was no obvious opening of the pleura; by aspiration and injection of penicillin it may be possible to control this, or if an empyema develops it will require drainage.

The other dangers after the operation are a spread of the pneumonic process with the formation of fresh lung abscesses and the development of a cerebral abscess This last may show itself quite late in convalescence and perhaps, most bitter of all, when the lung condition is cured and the patient about to leave hospital.

Instead of progressively obliterating, the abscess cavity may persist with one or more bronchial fistulae and with continuance of cough and sputum. This may be due to the extent of lung destruction at the time of the original abscess, especially if healing is so slow that epithelialization of the wall occurs from the damaged bronchi. In most acute cases, providing the abscess is drained early when the walls and surrounding lung tissue are relatively soft and recoverable, rapid and steady obliteration occurs; even a big abscess cavity, in which much lung destruction might be inferred, may be due chiefly to distension from bronchial obstruction and will rapidly contract down once it is drained.

The longer time the drainage has been delayed, however, the more likely are secondary fibroid changes to be present in the lung around the abscess cavity, which is also held open by dense and wide pleural connections; a chronic cavity with fistulae persists and bronchograms will often show considerable associated bronchiectasis. In the absence of bronchiectatic changes it may be possible to obtain healing by means [illegible] into the cavity. If bronchiectatic or severe 'cys[illegible] lobectomy or even pneumonectomy is needed. [illegible] this the patient may just have to continue with a discharging sinus.

In any case of delayed healing tuberculosis or growth must be carefully excluded, even if earlier search has been made. Tuberculosis often occurs as a secondary invader in cases of chronic lung abscess.

Comparison of the Results of Expectant Management and of Operation

The need for early operation in the acute foetid type of lung abscess has been particularly stressed by Neuhof and Touroff (1936), and the figures they produce bear out their contention Thus in their last paper (1942) they report only 4 deaths in 154 acute cases treated by operation, a mortality of 2·6 per cent. The only other authors to report a series of acute cases with such a low

mortality are Lindskog (1944), whose mortality was 4·5 per cent in 22 cases of less than two months' duration, and Overholt and Rumel (1946), who gave a mortality of 6 per cent in 35 cases of less than six weeks' duration.

My own experience of operation on acute foetid lung abscess is somewhat limited and amounts to 34 cases of whom 11 died (28 per cent); if acute non-foetid cases are included the total operated on in the acute phase (less than six weeks) is 60, of whom 15 died (25 per cent).

In spite of the fact that the mortality following early external drainage is not so low in the general literature as in Neuhof and Touroff's series, there still remains an unanswerable case for treatment by early operation *as soon as it has been established that steady clinical and radiological resolution is not proceeding.* If clinical and radiological resolution is unsatisfactory, incomplete, or interrupted in the presence of adequate chemotherapy and other expectant measures, mechanical factors must exist interfering with adequate drainage and inviting relief by operation. If a high mortality is still associated with early operation it is more an indication of the gravity of the infective process itself than of the inadequacy of surgery. Rives, Major, and Romano (1938), for example, analysed 100 fatal cases of lung abscess and found the mortality in acute cases admitted during the first four weeks of the disease was 56 per cent, in those admitted between the fourth and eighth weeks 15 per cent, and between the second and third months 9 per cent. The lower mortality in the later cases is apparently due to the fact that the graver cases had died before admission, thus reflecting the initial high mortality of the condition itself.

In some cases of acute foetid lung abscess the process is so severe that Neuhof and Touroff (1946) have rightly suggested that a separate group of hyperacute abscesses should be recognized and the need for urgent surgery in them widely appreciated. They suggest that the following radiological features point to the need for prompt interference.

1. Substantially more infiltration in the wall of the abscess than is seen in acute abscess.
2. The abscess cavity may present an irregular or scalloped border due to attachment of gangrenous pulmonary sloughs to the walls.
3. Pleural reaction about the abscess is often both intense and extensive.

Although the advantages of early surgery have been emphasized, experience with a large number of cases has impressed one with the fact that it is, unfor- unately, uncommon for patients to be referred for treatment in the acute hase (i.e. up to within six weeks of the onset of the illness). It is far more ommon to find that many weeks and, even more unfortunately, often many onths have been allowed to pass before it has been appreciated that some- ing more must be done. Thus during the years 1942–50, in which 318 cases

of non-malignant lung abscess were seen, the proportion of acute and chronic forms was as follows:

TABLE XIV

ANALYSIS OF 318 CASES OF NON-MALIGNANT LUNG ABSCESS

Total acute	142
Total chronic	176

The reason for this lies in the persistence of the belief that a high proportion of cases resolve under expectant management and with a lower mortality than with surgery. This is not borne out by examination of actual figures. The literature contains a certain number of reports of cases in which valid comparison has been made between the results of surgical and medical treatment, but in many reports no proper comparison is made Accordingly in 1942 I decided to keep records of all cases of lung abscess seen personally so that it would be possible to form at any rate some opinion of the comparative course of events. The following tables show the results observed in the years 1942–50 inclusive.

TABLE XV

COMPARATIVE RESULTS OF SURGICAL AND NON-SURGICAL TREATMENT (1942–50)

Total cases (non-malignant) = 318			
Operation		*No operation*	
Total	123	Total	195
Died	23 (18·7%)	Died	22 (11 3%)
Cured	91 (74%)	Cured	130 (66·7%)
Chronic	9 (7 3%)	Chronic	43 (22%)
		But add 123 who came to operation	166
Total mortality (medical and surgical)			45 (14%)

From the fact that expectant management was pursued in 195 cases (60 per cent), it will be seen the approach to the problem was not unduly radical.

It is often found that when a report is being presented of the results of 'medical treatment' of lung abscess, no account is taken of those cases occurring during the corresponding period in which surgery became necessary, i.e. in which expectant management failed. This is, of course, a serious omission. Clearly, any case in which operation is needed represents a failure of expectant management. Thus, in the above series, the 123 cases in which operation was needed must be added to the 43 in whom non-resolution

occurred under expectant management alone. The whole series of results of expectant management needs correcting as in the following table:

TABLE XVI

CORRECTED RESULTS OF EXPECTANT MANAGEMENT IN 318 CASES

Total cases	318	
Cured	130 (40·8%)	
Died	22 (7%)	59·2%
Non-resolution	166 (52·2%)	

It will thus be seen that expectant management resulted in cure in only 40 per cent of the cases, and that death or failure of resolution occurred in 60 per cent. In contrast, in those in whom operation was needed, 74 per cent were cured, and it must be remembered that this figure was obtained in those very cases which were the failures or rejects under expectant management. It is quite wrong, often even naïve, to assess the results of surgery and of non-surgical measures without making this correction.

The results of operation (including lung resection) in all my cases (1933–50) are as follows:

TABLE XVII

RESULTS OF OPERATION (INCLUDING RESECTION) IN 199 CASES (1933–50)

Total	199
Died	47 (23·75%)
Well	131 (65·75%)
Chronic	21 (10·5%)

If those cases treated by lobectomy or pneumonectomy are excluded the results are not so good.

TABLE XVIII

RESULTS OF OPERATION (EXCLUDING RESECTION) IN 136 CASES

Total	136
Died	40 (31%)
Well	76 (56%)
Chronic	20 (13%)

In the course of making the above analysis of my own figures I had the pleasure of reading the admirable paper by Smith (1948) on the *Medical Treatment of Acute and Chronic Pulmonary Abscesses.* This lucid and well-balanced contribution should be consulted by all those interested in this subject.

He refers to Allen and Blackman (1936) who in 1936 collected 2,114 cases of lung abscess from the American literature and found that the mortality in patients receiving medical treatment was 34·4 per cent and in those receiving both medical and surgical treatment was 34·2 per cent. Smith has collected a further 2,116 cases from representative clinics since 1936, and finds that the gross mortality remains at 34·2 per cent. Among 906 patients receiving medical treatment the mortality was 34·7 per cent, while the mortality among 744 treated by operation was 32·7 per cent. The combined table he gives is as follows:

TABLE XIX

COLLECTED FIGURES PUBLISHED BY SMITH (1948)

Surgical		*Medical*	
Total	744	Total .	906
Died	243 (32·7%)	Died .	. 314 (34·7%)
Well	343 (46·1%)	Well .	284 (31·3%)
Chronic	. 158 (21·2%)	Chronic	308 (34%)

The list of authors from whom these figures were obtained is contained in Smith's article.

Smith has, however, also realized the need for making a correction of these figures similar [illegible] He states that although the r[illegible] ed surgically is not much bett[illegible], 'a better idea of the results of medical treatment can be obtained by considering all the patients as being medical patients before they underwent operation.' The corrected figures he then produces for the results of medical treatment are as follows:

TABLE XX

CORRECTED RESULTS FOR EXPECTANT TREATMENT (1,498 CASES)

Total cases . .	1,498	
Cured . . .	284	
Died . . .	314 (21%)	81%
Chronic . . .	900 (60%)	

It will be seen that this correction reduces the medical mortality to 21 per cent, but the recoveries are only 19 per cent and, most significant of all, 60 per

cent of this series of 1,498 patients were still chronically ill after medical treatment. Only 19 per cent were cured; expectant management was a failure in 81 per cent.

Smith comments that 'not only is the percentage of failures greater with medical treatment, but the patients are generally in much poorer condition and usually are not able to work, while many of the patients listed as chronic after surgery have only minor disability and are able to earn their living.' This comment I would heartily endorse.

It should be mentioned that Smith is a physician and not a surgeon. A further comment he makes is: 'Speaking as an internist, it is my impression that the general practitioner and the internist, not the surgeon, are primarily responsible for the conditions which result in the death of one-third of the patients who develop primary pulmonary abscesses '

Klepser and Davis (1950), in a more recent paper, report on 247 cases of lung abscess seen between 1943 and 1949, all of which had been treated with bronchoscopic aspiration and chemotherapy, the latter ones with antibiotics as well. The deaths totalled 34 (13·7 per cent) Those classified as undergoing non-operative treatment are recorded as follows:

Total	70
Cured	58 (82 8%)
Died	5 (7%)
Chronic	7 (10 2%)

But here again it is necessary to correct these figures by adding to the failures those 119 cases who came to operation. The picture is then·

Total	243	
Cured	58 (23 5%)	
Died	5 (2%)	76 5%
Unrelieved or chronic	126 (74 5%)	

Once again we see that expectant management failed in nearly 80 per cent and 23 5 per cent alone were cured.

There should really be no contention for pride of place between medicine and surgery in the treatment of lung abscess. Both have their place and, *provided the limitations and indications are clearly recognized and observed,* there need be no invidious comparison. The simple fact is that some patients do well without operation, some need operation. It is for us to try and seek out and respect the factors that decide these issues. The competent and well-balanced surgeon tries to be as dispassionate in his assessment of each case as the careful and experienced physician; both should be able to recognize equally when surgery is needed and when it is not With good team-work there is rarely any conflict of opinion between physician and surgeon in these cases; what is so undesirable is the attitude of mind that looks upon surgery with abhorrence

and persists in a policy of its avoidance at all costs; not infrequently to the grave detriment of the patient. This practice, when it does not lead to the patient's death, allows him to drift into a condition of chronicity in which restoration to normal health is either impossible, or is achieved only by more severe and more dangerous procedures than would otherwise have been necessary.

Lobectomy and pneumonectomy in lung abscess

The assessment of the results of expectant management and of operation in the treatment of lung abscess reveals that without operation the results are bad in a high proportion of cases (60–80 per cent). On the other hand, the mortality and morbidity of external drainage leave much to be desired. A mortality of 25–30 per cent is considerable, even allowing for the fact that many of the patients coming to operation are late neglected cases suffering from extensive lung suppuration and near to death; cases in which surgery is demanded as a last and desperate attempt to save life, instead of being used intelligently at the proper time.

The chief causes of death after external drainage are septic pneumonia, secondary haemorrhage, or cerebral abscess; pleural suppuration and other infective complications are less common. The chief reason for these serious complications is that infected lung is cut into, and during the period of drainage, which may last weeks or even months, is exposed to numerous mechanical derangements due to breathing, coughing, pressure of drainage tubes or packs, etc. The actual operation of external drainage, if performed skilfully, should be no burden to the patient; the high mortality is due to the secondary occurrences which may appear when the patient seems to be doing well and on the way to complete recovery. The sum total of the high mortality of the treatment of lung abscess, whether medical or surgical, reflects no great credit on us, even when we acknowledge a definite improvement during the last ten years, due to the introduction of chemotherapy and antibiotics and of better general management.

The practice of persisting with expectant management for two to three months before considering surgery results not only in a higher mortality, but a higher proportion of cases in which permanent damage to the lung remains. In the chronic case the walls of the abscess and the surrounding lung tissue are fibrous, rigid, and contain many smaller areas of chronic suppuration; the bronchi develop permanent bronchiectatic changes. Early resolution after drainage is, therefore, prevented; secondary haemorrhage is more likely to occur, and even when most of the infection has subsided, a chronic fibroid lung with bronchiectasis, or a chronic abscess cavity or cavities remain. These permanent changes are a constant menace to the patient's health and constitute a further danger to his life. The cutting short of the infective

process by early external drainage in order to avoid these permanent lung changes is one of the greatest arguments in favour of early operation. The imperfect results, both immediate and remote, that follow external drainage performed when the acute stage of suppuration has passed indicate the need for excision of the diseased lobe or lung rather than ordinary external drainage. No other conclusion is possible from this consideration of the high mortality and danger of chronic secondary changes.

Moreover, it should be noted that the mind of the thoracic surgeon to-day is turning away from external drainage to resection of lobe or lung when resolution is still incomplete after six to eight weeks. In contrast, the minds of many physicians are just beginning to turn towards external drainage when this stage is reached. Could there be any greater contrast in the approach to a major problem than this? The one conception is that the proper time for surgery has been reached, the other is that the proper time for conservative surgery has already passed, that radical resection is needed.

Actually, the principle involved is even wider than this. If one surveys the field of surgery as a whole one is impressed with the fact that everywhere the trend is away from operations involving two stages or delayed healing with prolonged drainage towards one-stage operations providing primary healing. This is a movement that can be observed in surgery in every part of the body, and is one of those subtle and yet irresistible changes of thought and policy just as real as the change in political and social thought that we see around us.

If one studies the literature of the surgery of lung abscess during recent years it at once becomes obvious that most thoracic surgeons' views and practice are evolving in the same way, except in very early cases. The number of articles on resection for lung abscess increases steadily year by year.

Glover and Clagett (1948) present the position clearly and simply in a recent report on 37 of their own cases; their article is characteristic of many others written in a similar strain (e.g. Lindskog (1944), Shaw and Paulson (1948), Kent and Ashburn (1948)).

Glover and Clagett point out that so long as a conservative programme of six to twelve weeks exists before surgical treatment is applied, no better results can be obtained. They rightly emphasize that although 25-30 per cent of cases heal by medical means alone, the course of any one case is unpredictable, and the problem is, therefore, a surgical one. In contrast to the poor results of late external drainage they give their experiences in 37 cases in which lobectomy or pneumonectomy was performed. The average duration of the disease from diagnosis to resection was eighteen months, the extreme being eleven years. In 21 cases of lobectomy there was 1 death (4·8 per cent); the remaining 20 were cured. In 16 cases of pneumonectomy good results were obtained in only 7; there were 6 deaths (37·5 per cent) and 3 late deaths from brain abscess.

Lindskog (1944) reports 24 cases of resection which included 14 treated by primary lobectomy with 1 death and 12 good results; and 10 treated by secondary resection with no operative deaths, although there were 2 later deaths from cerebral abscess. The total mortality was therefore 3 out of 24 (12·5 per cent).

Shaw and Paulson (1948) report primary resection in 52 cases with cure in 43 (82·7 per cent), and an unsatisfactory result in 7 with 2 deaths (3·8 per cent). There were no deaths amongst 8 cases of secondary resection, and all were cured. The mortality in their total of 60 cases is, therefore, 2 (3·3 per cent).

Kent and Ashburn (1948) report 30 cases with 2 deaths (6·6 per cent).

Klepser and Davis (1950), in an analysis of 177 cases submitted to operation between 1943–49, report resection in 58 (lobectomy 41, pneumonectomy 17); there were 4 deaths (6·9 per cent) and 50 cures (86·2 per cent). In contrast, the mortality in 119 cases of external drainage was 25 (21 per cent), with 80 cures (67·2 per cent); 9 were submitted to secondary resection.

My own experience is as follows:

TABLE XXI

RESULTS OF RESECTION FOR LUNG ABSCESS IN 63 CASES

Lobectomy	45..3 deaths
Pneumonectomy	18..4 deaths
Total	63..7 deaths (11%)

The combined results of resection for lung abscess appear in Table XXII; it will be noted that the overall mortality in 272 cases is 9·2 per cent, and that a good result was obtained in 82 per cent of cases. These results are overwhelmingly superior to those obtained by any other method, and it must

TABLE XXII

COMBINED RESULTS OF RESECTION FOR LUNG ABSCESS

Author	*No. of cases*	*Good result*	*Died*	*Mortality*
Glover and Clagett	37	27	7	19%
Lindskog	24	20	3	12·5%
Shaw and Paulson	60	43	2	3 8%
Kent and Ashburn	30	28	2	6 6%
Brock	63	55	7	11%
Klepser and Davis	58	50	4	6·9%
Total	272	223 (82%)	25	9 2%

be remembered they were secured mostly on late and often neglected cases in which other methods of treatment had failed

My own series of 63 cases includes operations done as far back as 1935 and 1936 (primary lobectomy for chronic lung abscess); the earliest pneumonectomy for chronic lung abscess in the series was done in 1939, eleven years ago. In 9 of the earlier operations (8 lobectomies and 1 pneumonectomy) the older tourniquet technique was used, with the attendant greater risk of fistula formation, empyema, and secondary haemorrhage. In all the other operations a dissection technique was used with individual treatment of the hilar structures. It is, of course, the perfection of the technique of dissection lobectomy and pneumonectomy that has permitted the confident application of resection to cases of lung abscess. Upper lobectomy, for instance, for chronic lung abscess was a most hazardous procedure by the older tourniquet method, as a chronic empyema with fistula and an imperfectly expanded lower lobe almost certainly resulted. To-day one unhesitatingly expects primary healing in all but the exceptional severe case. The improvement in technique is shown by the fact that there has been only 1 death in the last 34 consecutive lobectomies and 1 death in the last 11 pneumonectomies

The results in all but one of those who recovered was satisfactory, and in most of them could be described as excellent. In this field of resection for chronic lung abscess the whole outlook may be so rapidly and completely changed from an impossibly dangerous and miserable position to one of rapid and complete cure that one is frequently entitled to describe it as a triumph of surgery. The miserable state of the unfortunate patient who has been coughing up many, many ounces of purulent offensive sputum a day, and who has lost all hope of relief, can be transformed almost overnight Equally dramatic can be the relief of that other dread terror that may attack the patient with a chronic lung abscess, recurrent massive haemorrhages

Case 3

Mr J H, aged 37, was first seen in August, 1945, with a history of productive cough and pain in the right side of the chest for sixteen months; there had been temporary improvement followed by one large and three small haemoptyses, totalling about 1½ pints The cough after this became worse and the sputum was offensive.

Complete examination revealed a small abscess with chronic pneumonitis in the posterior segment of the right upper lobe and a similar lesion in the apical segment of the right lower lobe He improved considerably on routine treatment, and although there was not complete radiological clearing, it was felt that pneumonectomy (which would have been necessary) was scarcely warranted He was discharged and told to report in two months for re-examination

He did not attend again until the end of December, 1946, fifteen months after his discharge During this time he had been too unfit to do more than three months' work; he had five attacks of cough and sputum up to two ounces, with staining He was advised to come into hospital

Within a week or two he began to have large haemoptyses and was admitted gravely ill on January 27, 1947; he had had five large haemorrhages which were said to have totalled

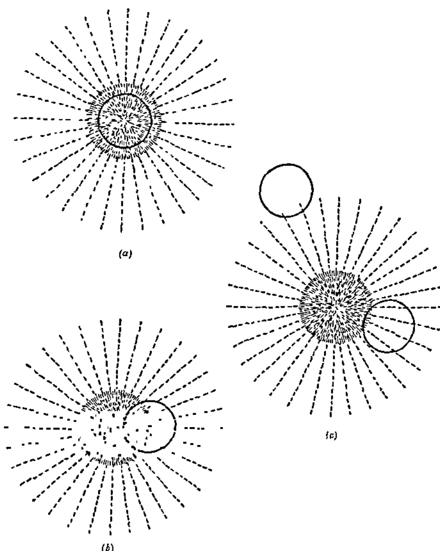


FIG 54. Diagrams to illustrate (*a*) perfect localization of lung abscess at operation; (*b*) the adherent area of pleura is only partly exposed, (*c*) poor localization.

several pints; the sputum was offensive. Radiographs of the chest showed a chronic abscess in the two original sites and also in the subapical segment of the right lower lobe. It was clear that pneumonectomy would be needed

A left bronchogram was done which showed minimal changes in the lingula, insufficient to contra-indicate right pneumonectomy Following this bronchogram he began to bleed again and had several massive haemoptyses totalling many pints in all. He had been given a blood transfusion of two pints, but was pale and listless with a haemoglobin below 30 per

cent, he was still bleeding and it was clear that operation alone could save him although he was quite unfit to stand it then. A further five pints of blood were given, and during the next [illegible]

Examination of the specimen confirmed the presence of chronic abscess cavities in the sites mentioned; the bleeding had come from the abscess in the apical segment of the lower lobe which was full of blood-clot; the other cavities contained foul pus and all were surrounded by dense fibrous tissue

The recital of bare statistics often fails to give an adequate picture of the human problems themselves. The following case-histories have been selected as representative of certain aspects of the problem

Case 4

Mr A S , aged 35, was first seen in April, 1940, with a foul abscess of the subapical segment of the left lower lobe which had followed tooth extraction one year before It was a small abscess and there was some improvement on expectant management, but as resolution was incomplete, operation was advised The reaction of the physician to this suggestion was to discharge the patient forthwith

He was not seen again until 1945, five years later, when he was aged 40 Survey of the radiographs showed progressive phases of secondary abscesses in the left lower lobe which was now a fibrous bronchiectatic structure with many small cavities He looked ill, had advanced clubbing of the fingers (Grade IV), and his sputum, which had never remitted, now amounted to five ounces of thick pus each day Lobectomy was advised

While he was awaiting operation he complained of feeling unwell and new radiographs showed two areas of infiltration in the right lung in the posterior upper segment and the lateral segment of the middle lobe, he had clearly had a spill-over infection Fortunately, these lesions cleared without permanent damage and left lower lobectomy was later performed without event He made an excellent recovery and is now completely free from all cough or sputum for the first time for over six years He was fortunate not to have succumbed to his chronic lung suppuration during these years

The next case illustrates a number of important practical features

Case 5

Mrs E M , aged 51, swallowed a rabbit bone on January 3, 1946, and suffered painful dysphagia for several days One week later she developed a sudden severe cough and brought up half a cupful of foul sputum She felt ill, feverish, and shivery. A month later she was admitted to a hospital where radiographs revealed an abscess in the posterior segment of the right upper lobe She was given sulphonamides and discharged after one month as there was [illegible]




R





FIG 55 Radiographs of Case 5
FIG 55a Shows the original abscess in the posterior apical sub-segment or posterior segment of the right upper lobe (February 2, 1945)
FIG 55b The original abscess persists and there is now a new abscess with a fluid level in the lateral part of the anterior segment (May 29, 1945)
FIG 55c The lateral anterior abscess is represented by an empty, thin-walled space, the original abscess persists (June 20, 1945)

posterior segment of the right upper lobe still present and a new abscess with a fluid level in the lateral anterior sub-segment Unfortunately, a bronchogram had been done and the lung contains much residual lipiodol Bronchoscopy revealed the characteristic foetor of a lung abscess but *no foreign body. The new abscess was making her so ill that* lobectomy seemed unsafe and she was treated expectantly for a week. There was no improvement and I reluctantly decided to perform external drainage of the new abscess as a preliminary to later secondary lobectomy. (I would to-day not hesitate in similar circumstances to perform *immediate primary lobectomy*) Fortunately, she suddenly improved and by June 20 there was only an empty abscess cavity in the lateral anterior sub-segment in addition to the older opacity (Figure 55*c*)

Here again those who follow a conservative policy would probably protest that with such improvement she should be left alone to continue to heal herself It was, however, felt very strongly that lobectomy must be done because, quite apart from the fresh abscess, the old lesion was still present and had already shown it constituted a grave menace The correctness of this decision was revealed almost at once, for two days before the day fixed for operation she again became ill and radiographs (Figure 56) showed a severe flare-up in the lateral anterior abscess.

Right upper lobectomy was carried o
rapid recovery. She healed by primary
all cough and had gained two stone in
appearance of the chest and also the absence of all external deformity.

Examination of the specimen showed a chronic abscess cavity lying in an area of chronic pneumonitis in the posterior and apical segments; a somewhat larger cavity 2 cm in diameter was in the lateral anterior sub-segment, and a small recent abscess in the anterior part of the anterior segment.

It *will* be noted that this patient was ill for six months with a steadily progressive, even though occasionally remittent, suppurative process in the right upper lobe which at any time might have proved fatal and certainly would have been fatal if it had not been cut short by a radical operation. Luckily the disease had remained confined to the right upper lobe; it might equally easily have spread to the lower lobe or even the opposite lung. A clean dissection lobectomy was able to control the process at once, and healing of the chest occurred by primary *intention.*

The good results following primary lobectomy, even in the presence of fairly … rform lobectomy even in the pr … l abscess cavity super-vening … this are shown in the following case:

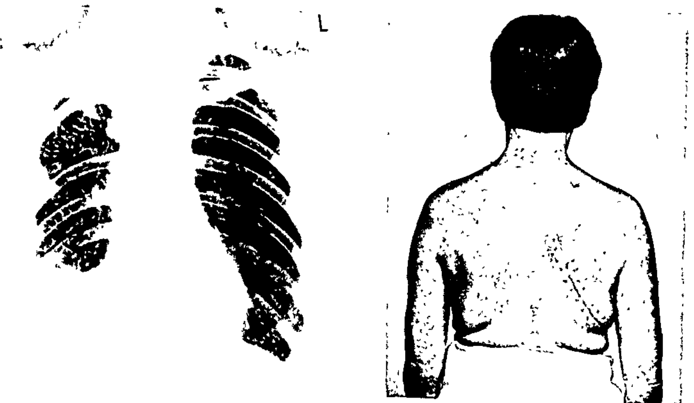
Case 6

Mr. P.N., aged 40, was taken ill suddenly on January 1, 1947, with acute pleuritic pain … oured sputum He was treated … putum gradually increased to



a b

Fig 56 Further radiographs of Case 5 The abscess in the lateral anterior segment, which seemed to be healing, has flared up, the region being consolidated (July 16, 1945)



a

Fig. 57a. Case 5 Shows the chest after right upper and middle lobectomy

b

Fig 57b Case 5. Shows the patient.

about 2·5 cm in diameter in the lateral part of the anterior segment of the left upper lobe In April, 1947, diabetes was diagnosed and he received insulin

His condition continued to deteriorate and he left Baghdad, where he lived, to come to the Brompton Hospital, where he was admitted on October 30, under Dr Scadding He was

left upper lobe

There was temporary improvement with intramuscular penicillin and then during the last few days of November the abscess suddenly increased greatly in size (Figure 58*a* and *b*), the sputum increased once again to eighteen ounces, he ran a high fever, and was in a miserably wretched condition and gravely ill

Operation was clearly essential, but it was difficult to decide on the best one to be used He was a big-framed, obese man, which made matters more difficult In view of the size of the abscess and the huge amounts of sputum there was clearly an argument for external drainage. It was felt, however, that this would entail a mortality risk of at least 25 per cent and would have to be followed by secondary lobectomy, which would be complicated by a drainage hole in the axilla After considerable deliberation it was decided to attempt primary lobectomy

This was done on December 1, 1947, a Thompson's tube (carrying an inflatable terminal balloon) was introduced so as to be opposite the left upper lobe bronchus in an attempt to prevent flooding of the bronchial tree Postero-lateral thoracotomy by resection of the fifth rib and division of the posterior end of the fourth revealed an unusually favourable state of affairs, the lower lobe was completely free from adhesions and was separated by a complete fissure from the upper lobe which was densely adherent over the area of presentation of the abscess. The pulmonary artery was exposed in the fissure, the lingular branch identified, tied, and divided, and the sentinel gland in the angle between the left upper and left lower lobe bronchi was defined and removed It was then, fortunately, possible to free the left upper lobe bronchus and to clamp it This early control of the lobar bronchus is most important, if possible it should be done before the lobe is dissected free at all so as to minimize the chances of spilling infected contents of the abscess Although occluding the bronchus by some internal device may be successful in preventing flooding, it can never be so certain as actual direct control of the bronchus by a clamp There is usually little difficulty in securing the bronchus within a few minutes of opening the chest if the surgeon develops his technique with this intent; the only difficulty may be in the case of the left upper lobe bronchus which is placed between the artery behind and the superior pulmonary vein in front, which may cause the freeing of the bronchus to be deferred until the vessels have been secured In this case it was extremely fortunate that the bronchus could be clamped so rapidly

It must be emphasized that manipulation of the diseased lobe must be reduced to a mini-

After the bronchus had been clamped, the upper lobe was now freed from the chest wall and at one site the outer covering of the abscess cavity was so thin that it ruptured and thick, foul pus and lung sloughs escaped

In spite of this, healing occurred by primary intention, atelectasis of the lower lobe the day after operation responded to a single bronchoscopic aspiration and the patient made an excellent recovery with complete and virtually abrupt loss of cough and sputum Figure 59*a* shows the final state of the chest The specimen is seen in Figure 60, the lobe is occupied by

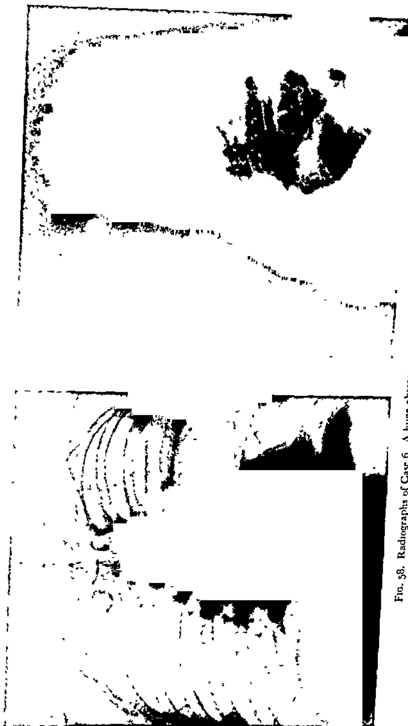


FIG. 58. Radiographs of Case 6 A huge abscess is seen occupying most of the left upper lobe

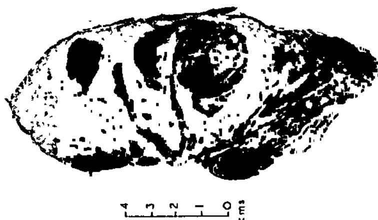


Fig 60



Fig 59

Fig 59 Shows the chest after lobectomy
Fig 60 Case 6 Photograph of the left upper lobe removed at operation The chronic abscess cavities are well shown

a chronic septic pneumonitis containing a system of large, intercommunicating abscess cavities, which in the fresh state contained a number of foul sloughs There is a sharp line of demarcation between the lingular segment, which was normal, and the remainder of the lobe which contained no air-containing tissue at all There is no growth

This case illustrates the brilliantly satisfactory result that can follow radical treatment. The grossly diseased and quite irrecoverable lung tissue is removed in one stage; the patient is at once relieved of his cough and sputum, and faces his convalescence without the burden of the horribly dangerous, infected lobe. *Once the hazard of the operation has been passed successfully, the* balance is weighted heavily in the patient's favour. In contrast to this, the actual operation of external drainage may present but little difficulty or danger, but the patient faces grave and increasing danger after the operation from the traumatized and heavily infected vascular lung tissue; in any event, permanent healing may only be achieved by a secondary lobectomy.

The successful results of this and other similar cases, contrasted with the perils experienced in the application of external drainage to late neglected abscess cavities, makes one confident that our best hope of securing a good result with the greatest safety lies in the greater use of lobectomy or pneumonectomy. Moreover, one inclines more and more to the use of lobectomy at an earlier and earlier phase in the treatment of a lung abscess that has failed to respond to expectant management.

REFERENCES

ALLEN, C. I , and BLACKMAN, J. F (1936) *J Thorac. Surg.* **6**, 156
ARBUCKLE, M. F. (1940) *Ann. Otol. etc* **49**, 821.
BATSON, O. V (1940) *Ann Surg* **112**, 138
BELK, W P (1926) *J Inf Dis.* **38**, 115.
BROCK, R C ·
(1936) *Guy's Hosp Rep* **86**, 191.
(1942) *Ibid* **91**, 111
(1943) *Ibid* **92**, 26, 82, and 121.
(1944) *Ibid.* **93**, 90
(1946) *The Anatomy of the Bronchial Tree*, London
(1950) *Thorax* **5**, 5
BROCK, R C , HODGKISS, F , and JONES, H O. (1942) *Guy's Hosp Rep* **91**, 131
BRULÉ, M , HUGUENIN, R , and GILBERT-DREYFUS (1927) *Bull et Mèm Soc méd des Hôp. de Paris*, **51**, 1370
BRULÉ, M , HUGUENIN, R , and FOULON, P (1927) *Ann d'Anat path.* **4**, 889.
BUCHER, G J (1930) *Amer J Med Sci.* **174**, 406
BULLOWA, J G M (1937) *Management of the Pneumonias*, New York.
BURDON, K L (1928) *J Infect Dis* **42**, 161
CECIL, R L., and PLUMMER, N. (1932) *J Amer Med Ass* **98**, 779
CHATARD, J A (1910) *Johns Hop Hosp Rep* **15**, 55
CHICKERING, H T , and PARK, J. H. (1919) *J Amer med Ass* **72**, 617
COHEN, J (1932) *Arch Surg* **24**, 171
COLE, R I (1927) 'Acute Pulmonary Infections,' De la Warr Lectures, Johns Hopkins University School of Hygiene and Public Health
COLLINS, L H , and KORNBLUM, K (1929) *Arch Int Med* **43**, 351
COLLINS, L H (1936) *Arch Int Med.* **58**, 235
COLLIS, J L , and FOSTER-CARTER, A F (1940) *Lancet* **1**, 875
COLLIS, J L (1944) *J Thorac Surg* **13**, 445
CROWE, S J., and SCARF, J E (1928) *Arch Surg* **16**, 176.
[illegible]
[illegible] 29) *Arch Surg* **19**, 1292
[illegible] *Med* **52**, 249
GLEICH, M (1932) *Arch Pediat* **49**, 258
GLOVER, R P , and CLAGETT, O T (1948) *Surg Gynec and Obstet* **86**, 385
GRAHAM, E A (1926) *J Amer. med Ass* **87**, 806
[illegible] (1947) *Lancet* **2**, 752
[illegible] 185
KENT, E. M , and ASHBURN, F S (1948) *J Thorac Surg* **17**, 514.

KESSELL, L. (1930) *Arch. Int Med* **45**, 401.
KING, D. S, and LORD, F. T. (1934) *Ann intern Med.* 8, 468
KLEPSER, R G, and DAVIS, E W. (1950) *Dis of Chest* **17**, 172.
KORNBLUM, K. (1928) *Amer J. Roentgenol* **19**, 513
KRAMER, K, and GLASS, A (1932) *Ann Otol etc*, St. Louis, **47**, 1210
KWALWASSER, S., MONROE, R. R, and NEANDER, J. F. (1950) *Amer. J. Psychiat.* **106**, 750.
LAWRENCE, J. S (1945) *Brit. med. J.* **1**, 871
LEYDEN, E, and JAFFE, M (1867) *Deutsches Arch f. klin. Med.* **2**, 488.
LILIENTHAL, H. (1928) *Arch Surg* **16**, 206.
LINDSKOG, G. E. (1944) *Surgery* **15**, 783
LORD, F. T. (1925) *Boston med. surg. J* **192**, 785.
LORD, F. T (1925) *Diseases of the Bronchi, Lungs and Pleura*, Philadelphia and New York.
LUETH, H. C. (1935) *Illinois med J* **68**, 440
LUND, E. (1945) *Lancet* **1**, 661.
MACCORDICK, A H (1931) *Canad Med Ass. J* **25**, 704.
MACKEITH, R. (1941) *Lancet* **2**, 354
MAXWELL, J (1934) *Quart J. Med* **27**, 467.
MÉTRAS, H., and LIEUTIER, J. (1947) *Thorax*, **2**, 196.
MOORE, W. F. (1922) *J Amer. med. Ass* **78**, 1279.
NEGUS, V E. (1934) *J Laryng and Otol* **49**, 571
NELSON, H P (1934) *Brit med J* **2**, 251
NEUHOF, H. (1940) *Dis. of Chest* **6**, 299
NEUHOF, H, and TOUROFF, A. S. W
(1936) *Surg Gynec and Obstet* **63**, 353
(1938) *Surgery* **4**, 728.
(1938) *Surg Gynec Obstet.* **66**, 836
(1940a) *J. Thorac Surg.* **9**, 439.
(1940b) *N Y State J Med* **40**, 849
(1942) *J. Thorac. Surg* **12**, 98
NEUHOF, H., and WESSLER, H. (1932) *J Thorac Surg.* **1**, 637
OVERHOLT, R H., and RUMEL, W R (1941) *New Engl. J Med* **224**, 441.
PRYCE, D. M. (1946) *J Path. Bact* **58**, 457
PRYCE, D M, SELLORS, H. T., and BLAIR, L. G (1947) *Brit J. Surg* **35**, 18
RABIN, C B (1941) *J Thorac Surg.* **10**, 662
REIMANN, H. R (1933) *J Amer. med Ass* **101**, 515
[illegible] **107**, 753.
[illegible]
(1930) [illegible]
(1938) *Proc R Soc Med* **31**, 1259
SCOTT-PINCHIN, A. J, and MORLOCK, H V·
(1932) *Lancet* **2**, 605
(1935) *Ibid.* **2**, 1369
SELLORS, H T. *et al.* (1946) *Thorax* **1**, 146
SHAW, R. E, and PAULSON, D L. (1948) *J Thorac Surg* **17**, 514.
SMITH, D T..
(1927) *Arch Surg.* **14**, 231.
(1932) *Fuso-Spirochaetal Disease*, Baltimore, 118
(1934) *J. Amer. med. Ass.* **103**, 971.
(1948) *J. Thorac. Surg.* **17**, 72.

STENGEL, A , KORNBLUM, K., and COLLINS, L H. (1928) *Tr A. Am Physicians* **43**, 326
STERN, L .
(1935) *J. Thorac Surg* **4**, 547.
(1936) *Ibid* **6**, 202
STIVELMAN, B P., and KAVEE, J :
(1946) *Ann Int Med* **25**, 66
(1947) *Lancet* **1**, 307
SUTHERLAND, A W , and GRANT, L. J. (1950) *Lancet* **1**, 530.
SWEANY, H C , STADNICHENKO, A , and HENDRICHSEN, K J (1931) *Arch Int Med* **47**, 565
TAYLOR, J W (1944) *Brit med J.* **2**, 500
TOUROFF, A. S W , and MOOLTEN, S E (1935) *J Thorac. Surg* **4**, 558.
TOUROFF, A S W , and NEUHOF, H. (1941) *J Thorac Surg* **10**, 618
VARNEY, P L (1929) *Arch. Surg* **19**, 1602
WARR, O S , and ALPERIN, J (1933) *Ann Int Med* **6**, 1474
WESTERMARK, N (1926) *Acta Radiol* **7**, 626
WHITTEMORE, W. (1924) *Surg. Gynec Obstet* **38**, 461

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